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ADAPTATIONS TO AQUATIC, ARBOREAL, FOSSORIAL AND CURSORIAL HABITS IN MAMMALS.

IV. CURSORIAL ADAPTATIONS.

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OF all portions of an animal's body to undergo specialization, those which have to do with locomotion show perhaps the most varied adaptations. Speed is so essential to a great number of forms, either for escape from the enemy or for the chase of prey, that its degree of development has much to do with the fitness of the creature for survival. This adaptation is most manifest in the modifications undergone by the feet and limbs, and to a less extent in the lengthening of the head and neck in long limbed forms as a necessary correlation. Speed adaptation is further shown in the moulding of the contour of the body to lessen the resistance of the air, an increase in the capacity of the heart and lungs to meet the more rapid expenditure of energy, and finally in saltatorial forms an increase in the length and weight of the tail.

Most terrestrial mammals can run; but in comparatively few orders is there any special adaptation for speed. Offensive flight

occurs among predaceous mammals such as the carnivorous marsupials and the true Carnivora, while defensive flight is found among herbivorous forms both among the marsupials and in the placental orders Rodentia, Perissodactyla, and Artiodactyla.

Feet and Limbs: — The main foot adaptations are shown in the passage from a primitive plantigrade to a digitigrade or to an unguligrade condition, and in the reduction of the number of digits; the last being often accompanied by a close apposition or even by a fusion of the remaining bones of the metacarpus or metatarsus, and a reduction of the number of bones in the wrist and ankle. Cursorial adaptation leads to the formation of true ginglymoid joints in the carpus and tarsus, the motion being limited to flexion and extension though the angle of movement is increased. This motion is confined to the proximal podials, while the distal ones become flat and may either fuse with each other as in the Pecora, or with the metapodials as in the Tragulidæ. The development of tongue and groove joints mars the efficiency of the limb for other purposes than running.

The laws which govern digital reduction among vertebrates lead to an interesting grouping of the Mammalia with the Amphibia in which the order of reduction is first digit I then digit V as contrasted with the Sauropsida, the reptiles and birds in which the fifth digit is invariably the first to disappear, followed by digit I.

The axis of the mammalian foot may lie in digit III as in the perissodactyls and in most rodents though not in the Leporidæ; between digits III and IV as in the Artiodactyla and Carnivora, or in digit IV as in the diprotodont marsupials.

Another marked cursorial adaptation is the increase in length of the lower leg and foot both absolutely and in relation to the length of the femur; the lengthening of the limb increases the stride while the raising of its centre of gravity quickens the motion. This modification reaches its highest expression in creatures of moderate size such as the medium sized antelopes for in larger animals the increase in weight demands greater structural strength which limits the degree of such elongation.

The Carnivora whose need of cursorial adaptation, outweighed by a greater need of varied motion, is less than that of other

orders under consideration show the most generalized condition of feet and limbs ranging from the ancestral canid Cynodictis of the Oligocene and lower Miocene, in which both manus and pes are pentadactyl, though with functionless pollex, to Lycaon in which structural tetradactyly prevails. In most of the Canidæ the digital formula is manus 5, pes 4; the former being however functionally tetradactyl. A curious reversional condition is seen in many high bred domestic dogs in which a functionless hallux is present without skeletal connection with the rest of the pes, similar to the dew claws of cattle. The author has invariably observed this hallux claw in Saint Bernard dogs since he first noticed it, and it seems to occur in about fifty per cent. of fox terriers. Occasionally it is observed in other breeds but not so constantly and it probably never occurs in low bred individuals. I have recently observed a Saint Bernard with *two* hallux claws on each hind foot. Cats, with the exception of Cynælurus, the hunting leopard, are not addicted to running, as their run consists merely of a series of bounds, the creature slowing down as soon as possible, hence special cursorial modifications are hardly to be looked for outside of the genus mentioned. In Cynælurus the compact feet, poorly retractile claws and dog-like proportions and musculature show an interesting case of convergence toward the Canidæ.

As in Lycaon the hyænas have also reached a condition of structural tetradactyly, the most extreme case of digital reduction to be met with in the order.

Among the polyprotodont marsupials the Tasmanian wolf, Thylacinus, which lacks only the hallux shows thus the same digital reduction as in the majority of Canidæ though the feet are much less specialized. The diprotodont marsupials on the other hand exhibit extreme modifications both for running and jumping.

Of the diprotodont marsupials the Peramelidæ, the bandicoots, exhibit decided cursorial modifications. Disparity of size exists between the fore and hind limbs, and there is aside from this fact a further kangaroo-like reduction of the pes. The hallux is very much reduced; digit IV is on the contrary the dominant one, while digits II and III are syndactylly united to offset

digit V. In Peragale the lateral digits, except the hallux, are subfunctional while in Chœropus the pes is functionally monodactyl although not structurally so. The manus of Peragale has five digits the three median ones being functional, with III as the dominant finger, while the external digits are functionless. The ungal phalanges on II, III, and IV are long and deeply cleft. In Chœropus digits I and II are reversional, digit IV being vestigial, while II and III are functional, III being as in Peragale, the dominant one.

From the digital modification observed in the Peramelidæ to that of the kangaroos is but a step, for while in the latter the manus is more generalized the pes has reached a higher degree of specialization in the total reversion of the hallux, the plan of modification being precisely as in the bandicoots. The more generalized pentadactyl manus, which shows no cursorial modification, would seem to indicate that the bipedal gait was acquired before speed requirements were met.

The Rodentia have five or six families in which true speed adaptation occurs; one, the Leporidæ, which have a combination of cursorial and saltatorial gait, the Dasyproctidæ and Caviidæ which are purely cursorial, and the Dipodidæ and Pedetidæ which are saltatorial.

In the Leporidæ, the hares and rabbits, the gait is a curious mixture of leaping and running. The wood rabbit, *Lepus sylvaticus*, when in a full gallop progresses in a manner similar to that of most quadrupeds, while the jack rabbit, *Lepus campestris*, which is a true hare, moves by a series of bounds, irregular in length, with all of the limbs moving synchronously, though the weight borne upon the fore limbs must be very slight, the powerful hind limbs giving the impetus to the body. The Leporidæ show no especial digital modification other than the simple reduction of the hallux. There is an elongation and greater compactness of the metapodium as in the Canidæ among the Carnivora, and the axis of the foot lies between digits II and IV.

Of the purely cursorial types the Dasyproctidæ are the more generalized though they exhibit two distinct stages in the reduction of the digits. The first is that of Cœlogenys, the paca, in which the manus and pes are both structurally pentadactyl

though the pollex is reduced, while in the foot but three digits are functional, the lateral digits being vestigial.

In Dasyprocta, the agouti, however, the hand remains distinctly pentadactyl though digits I and V are subfunctional, while in the foot the digits are reduced to three. Thus the foot is both structurally and functionally tridactyl, the metatarsals being closely pressed together though not fused. The compact pes thus formed is tending toward that possessed by the Dipodidæ (*vide infra*).

The Caviidæ, represented by the Patagonian cavy, Dolichotus, show a further reduction over Dasyprocta in that in the former the manus is tetradactyl while the pes is in the same stage of reduction in each.

Among the truly saltatorial rodents a range of specialization is shown, starting from Perodipus, in which the manus and pes are each pentadactyl though there is considerable disparity of size between the fore and hind limbs, the progression being by leaping with the hind feet. Dipodomys, the kangaroo rat, belonging, together with Perodipus, to the American family Heteromyidæ, has much the same proportions, but the pes is tetradactyl. In Pedetes, the African jumping hare, the pes is tridactyl, the median digit being much the longest; while in the true jerboas, as Dipus, the disparity between the limbs reaches its greatest development and the elongate metatarsals are fused into one very bird-like bone. The digital formula is manus 5, pes 3; but the clawless pollex is evidently undergoing reduction.

Among the ungulates I know of none in which cursorial adaptation is manifest, which have not already functionally lost the pollex and hallux, that is with the exception of Phenacodus among the condylarths which was pentadactyl and undoubtedly could run though exhibiting no very marked cursorial adaptation. In general, while the pes is often more specialized than the manus there is far more uniformity in the plan of modification of fore and hind feet than was observed in the rodents and diprotodont marsupials. The artiodactyl and perissodactyl stems have modified the feet in such different ways that it becomes necessary to give each group separate treatment.

Among the Perissodactyla, the rinocerotine group, mostly of

unwieldy build, contains but one family, the Hyracodontidæ, ranging in North America from the Bridger to the White River, in which a running type developed. Here the manus is tetradactyl, the pes tridactyl, and as Osborn[1] says: "Tridactylism is rapidly acquired with a tendency to monodactylism in the lower Oligocene." They strongly suggest the primitive horses in general contour.

The Equidæ are too well known to require more than a brief review. The pentadactyl ancestral form is as yet undiscovered and must be looked for in the Cretacic, for in the lower Eocene there appears Eohippus with a tetradactyl manus, the pollex being represented by a splint, and a tridactyl, elongated pes which bears a splint of digit V. The other Eocene horses exhibit the same stage of digital reduction as in Eohippus; but Mesohippus of the middle and upper Oligocene is tridactyl in the manus as well as in the pes, the fifth digit of the former showing a splint-like metatarsal, digit I being vestigial. Here all of the digits are functional the laterals finally losing their contact with the ground in Merychippus of the middle Miocene and in Neohipparion of the upper Miocene, a beautiful specimen of which has lately been added to the American Museum collection. Hypohippus of the middle Miocene with subfunctional lateral digits and, in the manus, the vestige of metacarpal V is an instance of arrested evolution owing probably to marsh dwelling habits which necessitated a spreading foot.

Finally the monodactyl type of the Pleistocene and Recent is represented by the genus Equus in which digits I and V are reversional and digits II and IV vestigial, being represented by the metapodial splints alone.

The Equidæ are curiously paralleled in foot reduction by the South American Litopterna in which the tridactyl condition with functionless lateral digits is shown in Proterotherium from the Santa Cruz formation, Lower Tertiary of Patagonia. This creature seems to parallel Merychippus, the main distinctions being that the former has rather more slender phalanges in the middle digit while those of the lateral digits are proportionately

[1] Osborn, H. F. The Extinct Rhinoceroses of North America. *Mem. Amer. Mus. Nat. History*, Vol. I, Part 3, p. 93.

more robust. The metapodials are shorter and stouter than in the horse, those of digits II and IV particularly being much more prominent.

Thoatherium from the same beds is monodactyl, the lateral metapodials being even more vestigial than in Equus which it parallels, and as in Proterotherium, the phalanges, especially the proximal and ungal of the remaining digit are much more slender than in the horse, the ungal being cleft. A curious admixture of perissodactyl and artiodactyl characters is seen in the feet of the Litopterna for they have the odd toed feet of the Perissodactyls together with the characteristic double tarsal joint, though not to so great an extent, of the artiodactyls.

The Artiodactyla early lose the hallux and pollex, for except in Oreodon and Agriochœrus we have no instance of their survival and while digits III and IV are equally well developed, II and V suffer all degrees of reduction from that seen in the swine to the total disappearance in the camel and Antilocapra.

The swine are four toed, the lateral digits being sub-functional. Dicotyles, the peccary shows an advance over most Suidæ in that digit V of the pes is entirely wanting giving an asymmetrical foot, of uncommon occurrence in the order though found in the Anoplotheres as well. In Dicotyles the metacarpals are slightly fused at their proximal end while in the metatarsals the fusion extends over half the length of the bones. The Pleistocene genus Platygonus shows a still greater specialization as it is structurally didactyl, but a splint of the fifth metatarsal remaining. The metapodial bones show a greater degree of fusion than in Dicotyles.

The Tragulidæ or chevrotains are in a sense transitional between the swine and the true deer for, while four toed, the lateral toes are functionless although in the existing genera Tragulus and Dorcatherium (Hyomoschus) the lateral metapodials are entire. Fusion of the median metatarsals to form a canon bone is found in Tragulus, but not in Dorcatherium which together with its somewhat better developed lateral digits presents a more generalized condition than does Tragulus. Gelocus, an extinct form ranging from the Eocene to the Oligocene, is more specialized than either of the existing genera in that the

lateral metapodials are incompletely ossified. The metacarpals are not fused, while the presence or absence of fusion of the metatarsals is a specific variation.

The extinct Oligocene genus Protoceras gives us an interesting example of the acceleration of the specialization of the hind limbs over the fore, for while the latter have four well developed functional digits those of the former are reduced to two only, with closely applied metatarsals which do not fuse, though strongly tending so to do. The lateral metatarsals are represented by proximal vestiges only.

In the Pecora or true deer the lateral digits are reduced, being functionless in most genera though sub-functional in Moschus and in Rangifer probably due, in the latter genus at any rate, to the necessity of a broad plantar surface for support on the mossy tundras or on the snow, a condition analogous to that of Hypohippus among the horses. In the deer the lateral metapodials are incomplete, their distal ends always occurring while only in certain genera as Cervus and Cariacus are the proximal extremities also retained.

The Bovidæ exhibit an almost complete reduction of the lateral digits, the dew claws being dermal appendages only, the proximal phalanges being invariably absent, while the final stage of total reduction of the lateral toes is found in the camels, the giraffe, and in Antilocapra. In the Bovidæ as well as in the later Camelidæ and the other forms mentioned the fusion of the metapodials to form a canon bone is complete.

In the later camels there is a retrograde descent from the unguligrade to the digitigrade condition, wherein the phalanges lie prone upon the ground, giving the characteristic broad, pad-like foot of the modern camel.

There are no instances of saltatorial adaptation among the ungulates though some antelope and deer are wonderful jumpers.

The lemurs among the primates present several instances of saltatorial adaptation, notably in the sub-family Galagininæ and in Tarsius, family Tarsiidæ; but here instead of an elongated metatarsus, which has been the rule heretofore, it is the tarsus which is modified, for the calcaneum and navicular become

lengthened and cylindrical as do the calcaneum and astragalus in the frog. The hallux is large and opposable while digits II and III are somewhat reduced, digit IV being the longest. In Tarsius digits II and IV are clawed while the others bear flattened nails.

The Skull.— Cursorial adaptation has its effect upon the skull only in the correlation that exists between long limbs and dolichocephaly, brought about by the necessity of reaching the ground on the part of a grazing animal. This is strikingly illustrated in the horse series where the increase in the length of the skull parallels the lengthening of the limbs.

Saltatorial forms which, like Dipus, have lengthened the hind limbs only, do not exhibit marked dolichocephaly, as the feeding habits of the creature do not require it. The grazing kangaroos however have a moderately elongate skull.

The Vertebral Column.— Cursorial adaptation among mammals is shown in the lengthening of the cervical vertebræ, especially in dolichocephalic forms, strikingly illustrated by the giraffe and by Alticamelus of the Loup Fork of Colorado [1] a camel showing the most remarkable convergence toward the giraffe, although the latter is derived from a totally different stock.

Among the saltatorial forms, especially those with brachycephalic skulls, the tendency is toward the shortening of the neck accompanied by a greater or less degree of immobility. In Pedetes cervicals 2 and 3 are so closely articulated as to eliminate motion, in Perodipus the axis and the next two vertebræ are fused, while in Dipus all of the cervicals except the atlas are coössified as in whales. There is no increase or diminution in the number of cervicals as a result of speed adaptation. The dorso-lumbar series seem to suffer little alteration in cursorial forms, though the lumbars increase in size in saltatorial types. The high number of vertebræ found in the horses is also found in other perissodactyls and in the Proboscidea, and so is not to be considered a modification coming within the scope of the present discussion. In some saltatorial forms, as the jerboas, an exceedingly short back is found; but saltatorial adaptation can exist without this feature.

[1] Matthew, W. D. *Mem. Amer. Mus. Nat. History*, Vol. 1, Part 7, p. 429, pl. XXXIX.

The tail is generally reduced as a result of cursorial adaptation, though in coursing dogs, as the grayhound and pointer, it aids in keeping the balance when the creature changes its direction and this may be a secondary cause for its retention. In saltatorial forms on the contrary, the tail becomes an important organ for use as a counterpoise; for in truly saltatorial mammals the tail increases in length and in weight directly with the increase in proportion of the hind over the fore limbs. It is in such bipedal forms as the kangaroos and the jerboas that the caudal counterpoise reaches its highest expression, for in the former the tail is long and heavy while in the latter the somewhat less proportionate weight is compensated for by the extreme length of the organ and the tuft of hair at its tip. The tail of the African jumping hare, Pedetes, is long and feather-like, like that of a squirrel. The development of a caudal counterpoise in bipedal mammals is paralleled among dinosaurs of the Mesozoic though, as the author will show in a forthcoming memoir,[1] dinosaurs are never saltatorial, but always progress by alternating strides. This is what one would be led to infer, for whatever the increase in speed may be, I know of no reptile which runs at a gallop that is with each pair of limbs moving nearly in unison, while among the mammalia this is the common method of rapid progression. The jerboas *walk* on the hind limbs with alternate strides, *hopping* only when speeding while the kangaroos have lost the more primitive alternate footed gait and use the hop for all degrees of rapidity. The hop may thus be considered as a sort of bipedal gallop.

Among the struthious birds, the cursorial habit evidently having been acquired after the loss of the reptilian tail, the counterpoising function is subserved by the wings which bear up the anterior part of the body and at the same time lighten the creature's weight.

COLUMBIA UNIVERSITY, DEPARTMENT OF ZOÖLOGY,
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[1] Lull, R. S., Fossil Footprints of the Jura-Trias of North America. *Mem. Boston Soc. Nat. Hist.* Vol. 5, no. 10.

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ON THE OSTEOLOGY AND SYSTEMATIC POSITION OF THE PYGOPODES.

R. W. SHUFELDT.

In a series of papers contributed to *The Journal of Anatomy and Physiology* of London (1889–1890) appeared a number of my drawings of the bones of pygopodine birds. Among these the osteology of certain grebes and loons was illustrated, but the material at hand then was meagre. Moreover, through an oversight the plate illustrating the bones of the lower extremity in the loons was omitted. The osteology of the pelvic limb in a loon is in a way more deserving of our consideration than perhaps other parts of the skeleton in those typical divers, and as I had fortunately preserved the aforesaid plate, I take occasion to publish it here.

In an article entitled "Concerning some of the Forms assumed by the Patella in Birds" (*Proc. U. S. Nat. Mus.* Vol. vii, 1884, pp. 324–331) I published two or three figures of the leg-bones in loons and grebes, but the descriptive text-matter had reference only to the morphology of the patella.

In the present memoir all of my previous work has been amplified and practically rewritten, while I have added my investigations upon the osteology of the Pygopodes.

In my classification of birds the Pygopodes appear in the scheme as a suborder, thus: —

Suborder: — PYGOPODES.

SUPERFAMILIES: —
- Podicipoidea.
- Urinatoroidea.

FAMILIES: —
- Podicipidæ.
- Urinatoridæ.

Newton in his classic 'Introduction' to his *Dictionary of Birds* (p. 111) makes the statement that the "group known as *Pygopodes* has been often asserted to be closely akin to the *Impennes*, and we have seen that Brandt combined the two under the name of *Urinatores*, but of their essential difference there can now be no doubt, and indeed it is hard to look upon *Pygopodes* as a natural group, so many are the differences between the *Podicipedidæ* or Grebes and *Colymbidæ*[1] or Divers, though recent morphologists agree to unite them, while the affinity of the Divers to the Auks seems to be still more uncertain, and there appears to be ground for considering the *Alcidæ* to be much modified relatives of the *Laridæ*."

The discovery of the toothed Hesperornithidæ of the middle cretaceous of America has doubtless modified the opinions of systematists regarding the affinities of the Pygopodes.

I agree then essentially with Fürbringer in confining the families Colymbidæ (loons) and Podicipidæ (grebes) to a group "Colymbo-Podicipites," and closely associating the latter with the families Enaliornithidæ and Hesperornithidæ in a Suborder Podicipitiformes. Therefore I can proceed to the consideration of the osteology of the grebes.

THE SKELETON OF THE GREBES.

Grebes may have the superior osseous mandible longer than the cranium, or they may have it shorter than that part of the skull. Of the first-mentioned, *Colymbus holbœlli* is a good example, while *Podilymbus podiceps* exhibits the latter characteristic. In *C. holbœlli* the long, straight and acutely-tapering superior osseous mandible is fully one fourth longer than the cranium, and either narial aperture is suboval in outline, being equal in length to the end of the bill which extends beyond its anterior termination. This narial aperture is rather acutely holorhinal posteriorly, and the dentary margins are cultrate for

[1] "American ornithologists have lately used this term for the Grebes, to the great disturbance of nomenclature. It is apparently from the ancestors of the *Colymbidæ*, before they lost their teeth, that *Hesperornis* branched off as a degenerate, bulky and flightless form." — A. N.

their entire extent. No part of the nasal septum ossifies in the skull (a feature common to all grebes that we have examined). Each nasal bone has a form much as we find it in the loons, its processes being flat and rather broad. The region over the cranio-facial hinge is moderately concaved, where the nasal processes of the premaxillaries are seen to be persistent throughout life, and their sutures plainly visible in the adult.

Posterior to this space the frontals between the superior orbital margins are much narrowed, and the supraorbital glandular depressions barely discernible, being distinguishable in the dried cranium only along their posterior moieties. The external superficies of the cranial vault in the parietal region are smooth and rounded; the crotaphyte fossæ are extensive and practically meet, mesially, over the large rounded supra-occipital prominence, though no median crest or line stands between them. More laterally, and upon either side, the occipital crest is raised and prominent. In the grebe now under consideration it is quite as thin, and lamellar-form as it is in the loons.

Upon lateral aspect of the skull, the post frontal and squamosal processes are much absorbed, and the valley between them wide. The aural entrance is extensive, very open and exposed, being overarched by its somewhat thickened postero-superior border.

Either zygomatic bar is straight, transversely flattened, and tapers slightly as it proceeds forwards where it assists in making a schizognathous articulation with the other bones.

The interorbital septum is markedly deficient in bone, and the anterior cranial walls about the exit of the nerves hardly less so. This deficiency is even greater than it is seen to be in the loons. Pars plana is weak and feebly developed, and externally, it passes upwards and forwards to fuse with the nether aspect of the frontal. A transverse perforation may normally exist just posterior to the true mesethmoid. This latter ossification terminates rather abruptly in front by a broadish face with a small median crest extending down it as far as the sharpened anterior apex of the rostrum, over which it is carried forwards.

A lacrymal is a fair-sized bone with a very narrow superior limb, closely articulating with its entire mesial border with the

frontal and nasal, while the rather larger descending portion of the bone is plate-like, being transversely compressed, and does not reach the maxillary below. At its apex it supports a spiculiform os uncinatum, as we find in the Urinatoridæ.

The foramen magnum is large, looks almost directly backwards, and is of an acute cordate outline, with the apex above. The occipital condyle is well developed, completely sessile, and barely notched superiorly. Passing to the basitemporal area we find it somewhat contracted, nearly level and smooth, while its anterior apex underlapping the double entrance to the Eustachian tubes. There are no evidences whatever of basipterygoid processes, and the long, straight pterygoids stand well away from the sphenoid. One of these bones has cultrate inner and outer edges or borders, and is peculiar in the way it articulates with the quadrate. The latter bone throws out a well developed apophysis, mesially, the summit of which is rounded to be received into the articular cup existing on the posterior end of the pterygoid. In most birds the pterygoids articulate upon the inferomesial border of the os quadratum. These bones in the grebe hardly touch each other anteriorly, where their palatine heads are to some extent expanded. The sphenoidal rostrum is comparatively slender and is carried to a sharp apex in front. The palatines have their postero-external angles completely rounded off, while their lower inner and outer margins are moderately bent downwards,— the inner one rather abruptly so. When articulated *in situ* these bones are in contact with each other all along beneath the rostrum. The antero-mesial portion of the post-palatine part of the bone, curls upwards and inwards towards the mesethmoid, and in front its mesial process runs forward as a long slender spine for the accommodation of the vomer. The prepalatine portion of a palatine is long, narrow and vertically compressed. Extending a long ways to the front, rapidly tapering to a point as it does so, the prepalatine underlaps the maxillary and maxillo-palatine, and passes along close to the inner aspect of the dentary part of the premaxillary, being thoroughly fused there in the adult. The suture, however, remains visible throughout life. For the size of the bird, Holbœll's grebe has one of the longest vomers at present

known to me. It is lamelliform, thin and narrow, its surface being in the middle plane, while behind it is moderately bifurcated, to be carried to a sharp apex anteriorly. Either maxillo-palatine is a subconcavo-convex oval plate of bone, of some little size. Its mesial surface looks inwards and upwards, the anterior fourth being fused almost indistinguishably with the nasal, maxillary, palatine and premaxillary. Palatines and maxillo-palatines are well separated from each other in the middle line, and from the vomer.

An os quaratum is rather a large bone in the grebes, with a long, gently-inturned orbital process. Its mastoidal head supports two facets of articulation, being separated from each other by a shallow sublongitudinal valley. Transversely, the quadrate is much compressed, and I have already described above the process at its infero-internal angle to accommodate the hinder end of the corresponding pterygoid. The mandibular portion is much excavated centrally on its nether aspect, with a small articular facette on either side of the concavity. There is also an articular line bounding this depression posteriorly. The bone appears to be pneumatic.

Passing to the consideration of the mandible we find it to be of the very acutely V-shaped pattern, with the ramal vacuity completely closed in. The articular ends are enlarged and abruptly truncated behind, where they show each a flat triangular surface. The ramal sides posteriorly are thin, lofty and flat, to become narrower and thicker as they pass tapering forwards to the acute apex. The symphysis is short, slightly excavated above, and rounded below. It is only the posterior extremities of the mandible that are at all pneumatic, the usual pneumatic orifice being at the end of the inturned, stumpy articular termination of the bone. Aside from the brevity of the superior osseous mandible in the short-billed grebes, the skull characters as given above for *Colymbus holbœlli* are substantially repeated in them. In *Podilymbus podiceps*, however, I observe that the anterior extremity of the vomer terminates in a small, rounded, disc-like nib, and its quadrates are rather more delicately fashioned. It also has the mesial notch on the upper side of the occipital condyle, and a mid-longitudinal raised line on the supra-

occipital prominence, which, as we shall see, is so much better marked in the loons. Finally, the supra-orbital glandular depressions are hardly perceptible in these dabchicks.

Grebes possess a hyoidean apparatus in some respects peculiar. It is well exemplified in Podilymbus, where we find the glossohyal performed entirely in cartilage, and the first basibranchial represented by an expanded suboval disc of bone. At the hinder margin of this the short second basibranchial, as a delicate osseous rod, articulates in the middle line, while the long, slender cerato-branchials, one on either hand, articulate close to it. The epi-branchials are short and spiculiform. We find a somewhat similarly fashioned first basibranchial in the tongue of the kingfishers, but such a form of it is rare among birds.

The sclerotal plates in the eye-balls of the Podicipoidea have their usual ornithic characters, being of moderate size only, squarish in form, and overlapping each other in the ordinary manner.

THE TRUNK SKELETON IN THE GREBE.

Birds of this superfamily vary, even for the genera, with respect to the number of vertebræ in the spinal column, and the corresponding vertebræ themselves vary much in form and character. Species such as *Colymbus holbœlli* and *Podilymbus podiceps* have 19 vertebræ in the cervical region of the spine, the 19th bearing a pair of ribs that do not articulate by costal ribs with the sternum.

But *Æchmophorus occidentalis* has 21 vertebræ in the cervical region, with the free ribs on the 21st as they occur on the 19th in Podilymbus. This last mentioned species has the first four dorsal vertebræ fused into one piece, but the fifth one, standing between this piece and the pelvis is free, and its ribs articulate with the sternum by costal ribs. There is also a pair of pelvic ribs, the hæmapophyses of which do not usually meet the sternum. All have large epipleural appendages, save the last-named; they being even found on the cervical pair. They do not fuse with rib borders.

In Æchmophorus the dorsal vertebræ do not fuse, although

the interarticulations are very close. This grebe has *two* pairs of pelvic ribs, the hæmapophyses of the first pair reaching the costal borders of the sternum. All grebes have large hypapophyses on the last two or three cervical vertebræ, and on all the centra of the dorsal vertebræ; they are very large in Æchmophorus, the first two being represented by flattened and out-spreading discs of bone of an irregular form. This species is also peculiar in having the neural spines of the 19th, 20th and 21st vertebræ much modified for muscular attachment. They resemble the ploughshare in form, being greatly increased in size, and the excavation occurring behind. The first (19th) has this modification most pronounced, while it is least marked in the ultimate one (21st). Parapophysial spines are quite aborted, or are represented by mere nibs of bone. Æchmophorus has the hypapophysial carotid canal extending through *twelve* vertebræ; it being generally closed in completely on the 9th and 10th one of the series. These vertebræ are the 4th to the 15th inclusive.

In *Podilymbus podiceps* I found 49 vertebræ in the spinal column. Nine free vertebræ and a pygostyle compose the tail of this bird, and when they are articulated *in situ*, they form a peculiar sigmoid curve, dipping downwards, then upwards, as the letter S. The pygostyle is very small and its characters much aborted.

Grebes have their caudal vertebræ considerably compressed in the transverse direction. In the dorsal region the tendons of the spinal muscles ossify and fuse with the summits of the neural spines of the vertebræ, and metapophysial spiculæ may also occur upon the transverse processes, as we find them in other water birds. Another thing is worthy of attention here, and that is the general form and outline of the skeletal parietes. Further along it will be seen that in the auks and puffins this is elongated,— the sternum being long, and the ribs sweeping far backwards beneath the pelvis. In the grebes this is not usually the case, for in Podilymbus the form of the thoracic skeleton is much as we find it in the gulls; in Æchmophorus, however, it is again more as in the Alcæ; it is quite so among the loons.

The form assumed by the pelvis among the Podicipoidea is

noteworthy; though in its general pattern it closely approaches what we find in the Urinatoridæ. The pelvis in *Æchmophorus occidentalis* well exhibits all the characters of this compound bone among the podicipidine types. In that species is much elongated and compressed laterally, especially its pos-acetabular portion. In front of the acetabulæ the fused sacral crista rises far above the fore part of the ilium on either hand,— which latter, each have the form of an oar-blade with a squarely truncated anterior extremity. An extensive antitrochanter surmounts either cotyloid cavity, while posteriorly the post-acetabular surface faces almost directly outwards. Along the dorsal middle line, for the posterior third, of the pelvis the iliac borders are closely pressed together, marking the uro-sacral vertebræ. Behind, a deep cleft indicates the division which originally marked the terminal point of union between the ilium and the very long and narrow ischium. The obturator foramen completely merges with the obturator space, and the much-extended, flat, ribbon-like post-pubic rod is widely separated from the lower ischiac border, being carried far back almost opposite the pygostyle. The ends of these bones of the pelvis, however, are not dilated as are the postpubic bones in the loons. The ischiac foramen is large, and of an elliptical outline. Podilymbus presents almost the same pelvic characters as those just described for Æchmophorus, and in this species the os innominata fuse completely with the "sacrum,"— though posteriorly the superior iliac margins do not quite meet over the uro-sacral vertebræ.

The sternum is very characteristic. In Figures 1, *a* and 1, *b* I have drawn it for *Colymbus nigricollis californicus* where its podicipidine features may be seen. Generally speaking it is broad and short, with a large subelliptical notch cutting out its xiphoidal portion on either side of the keel. This gives rise to a pair of flaring external xiphoidal processes, which curve outwards, then inwards, extending rather beyond the mid-xiphoidal prolongation. They are long and narrow in the short-billed grebes, and broader and relatively shorter in Æchmophorus and Colymbus. The mid-xiphoidal process always shows a triangular notch, which is much deeper in Podilymbus than in other species,

and it may also show certain foramina in the hinder part of the sternal body. The keel is triangular with a somewhat acute carinal angle produced in front, and closely approached by the os furcula when the bones of the shoulder-girdle are articulated *in situ*. Usually *six* articular facettes are found upon either costal border, and a costal process is large and subtriangular. No manubrium exists, and the bone is depressed where it occurs in the sternum when it is present. The costal grooves are noteworthy, for they are very deep, and their superior and inferior borders are produced well forwards.

As in the rest of the skeleton, save the hinder part of the skull and lower jaw, the sternum in the grebes is completely non-pneumatic.

Upon comparing the sterna of our various species of grebes, I find but few characters of marked difference beyond the matter of size. *Colymbus auritus* possesses a sternum most like that of *Podilymbus podiceps*, and next to it, in that respect, comes *Colymbus holbœlli*.

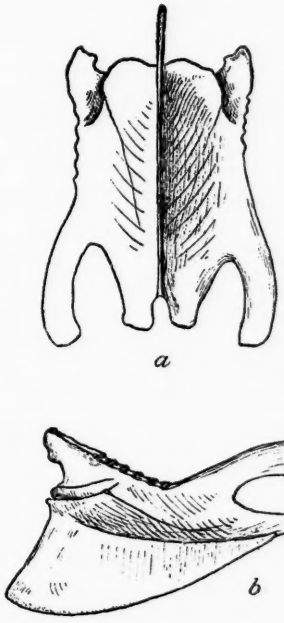

FIG. 1, *a*. Sternum of (*C. n californicus*) from below; *b*, left lateral view of the same bone. Natural size.

In the several bones of the shoulder-girdle, — the salient characters are the same for the various species of this group. The os furcula is always found to be of the broad U-pattern, much bowed to the front, without hypoclidium (*C. n. californicus*), and with narrow, laterally compressed limbs. Superiorly, the clavicular limbs taper out to acute points, and when the elements of the girdle are articulated *in situ*, one of these rests by its outer

aspect against the head of the corresponding coracoid, while the apex passes far over the anterior end of the scapula. Thus a piece of the clavicular end, including the apex, is above the scapula but not being in contact with it; — the actual point of contact between these two bones being several millimeters beyond or anterior to the apex.

The scapulæ are quite long, and narrow, being gently curved throughout their length in the vertical plane, the convexity being along the dorsal aspect. For the most part the bone is of uniform width, the head alone being somewhat thickened. It offers only a moderate articular surface for the coracoid, and the os furcula rests upon its upper side.

The scapulæ are especially slender in *Colymbus auritus*. Comparatively speaking, the coracoids are usually long and not very stout; they may, however, be only of moderate length. The summit of one of these bones offers us the usual ornithic characters, being peculiar only in having such a small scapular process, and being rather compressed laterally. The distal end of the bone is dilated and much flattened in the antero-posterior direction. This expansion is carried some distance up the outer side of the shaft, and, owing to the fact that the sternal end of a coracoid sets so deep in its articular groove in the sternum, the corresponding articular surface on the bone is carried up some little distance both in front and behind,— most so upon the latter aspect.

When the bones of the shoulder-girdle in a grebe are articulated as in life, there is quite an interval between their sternal ends, mesiad. As I have said above, this interspace on the sternum is concave and its convexity is coextensive with the inner border of the coracoid upon either side. A wide interval in the same location exists in *Hesperornis regalis*, the great diver of the Cretaceous epoch in America.

THE APPENDICULAR SKELETON OF THE GREBES.

As an example of the skeleton of the pectoral limb of an adult specimen of *Colymbus holbœlli* we have chosen No. 17815 Coll. U. S. Nat. Mus. In this specimen the humerus is 10.6 cms. long, with nearly a straight, subcylindrical shaft, the extremities

of which are but moderately enlarged. At the proximal end the radial crest is seen to be much reduced, and the excavation overshadowed by the low ulnar crest which is unusually shallow, with no evidences of pneumatic orifices. The articular surface of the humeral head has the ordinary avian character. Distally, the oblique and ulnar tubercles are prominent and offer considerable articular surface for the antibrachial bones. The ulna is 10.2 cm. in length, and considerably compressed subtransversely; the long, slender radius when articulated, *in situ*, with it, is in contact with its shaft for its distal moiety, thus much reducing the "interosseous space," which, in reality, only exists proximally. Manus has a total length of 8.3 cms., and the two usual free carpals are present in the wrist. Carpo-metacarpus is peculiar in being so comparatively long and slender, and for having the index and medius metacarpals so close together, and so nearly parallel. The phalangeal digits are long and slim, and I fail to find any "claws" upon the distal extremities of any of them. The proximal phalanx of the index digit is also elongated and remarkably narrow; the expanded portion and digital shaft being indistinguishably merged with each other.

The skeleton of the wing in *Podilymbus podiceps* has the same essential characters as in the wings of the long-billed grebes. In all, the bones are well-proportioned and harmonize in their lengths and calibres with the bones of the pelvic limb, in any given species.

Altogether one of the most beautiful adaptive structures is the pelvic limb of a grebe. When properly articulated, the short femur has its long axis directed from the acetabular center, downwards, outwards, and slightly backwards. By the structure of the knee-joint this brings the long axis of the tibio-tarsus almost parallel to the long, mesial axis of the pelvis. Now the tibio-tarsal articulation permits the exact play of the foot, by a fore and aft motion, at right angles to this long axis of the tibio-tarsus. It is an avian oar. The tarsus is compressed to the last degree consistent with strength, — so that when it and its blade-like toes make the forward stroke, the minimum amount of podal surface is offered to the water in resistance. But in the backward stroke of the foot, the articulation permits of the

reversal of this act, and the toes being turned, and to some extent the tarsus, the maximum amount of surface thus afforded is brought into play as in an oar. Femur and tarso-metatarsus have about equal lengths, and they each equal *half* the length of the leg-bones, measuring from the apex of the patella to the mid-lower point of the arc of the distal tibial condyles (*Podilymbus podiceps*). The mid-anterior toe in the adult measures 5.5 cm. and the tarso-metatarsus only 3.8 cm.; these are about the usual proportions.

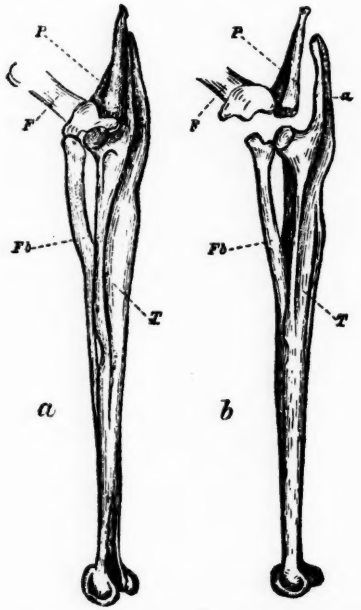

FIG. 2.— Leg-bones and patella of *Colymbus auritus*. *a*, the limb rotated slightly outwards; *b*, a square lateral view. In *a* the bones are *in situ*; in *b*, femur and patella are thrown backwards out of position. *a* rotular crest of tibia. P, patella; F, femur; *Fb*, fibula; T, tibio-tarsus. Natural size.

The head of the femur is large, and much excavated for the round ligament. At the summit the articular surface is rounded, and the trochanter does not rise above it. Its shaft is very slightly bowed to the front, and its condyles markedly prominent behind, with an unusually distinct and gaping cleft for the head of the fibula.

One of the most important characters of the tibio-tarsus is the upward extension of its cnemial crest, which is carried up to an apical process considerably above the summit of the shaft, but in direct line with the forepart of it. A large patella backs this at its supero-external aspect. It has something of the same form as the cnemial crest, above which it is slightly extended when articulated *in situ*. The procnemial ridge of the tibio-tarsus is extended as a sharp border down the

shaft of the bone; the latter being straight, flat anteriorly and rounded behind. Having the usual ornithic form, the tibial condyles are set rather obliquely on the distal end of the shaft. They are about parallel to each other. The fibula is very long with its lower end fused with the side of the shaft of the tibia. Superiorly, it is broad and flattened in the antero posterior direction, and stands well away from the tibial shaft (Figs. 2, *Fb.*).

Among the short-billed grebes the transverse compression of the shaft of the tarso-metatarsus is not nearly so evident as it is in such species as *Æchmophorus occidentalis* and *Colymbus holbœlli*. Moreover, in the dabchick there is a very slight twisting of the shaft upon itself, and this I have not observed in other grebes, either fossil or recent. At the summit of the bone, the articular excavations for the tibio-tarsal condyles are deeply sculpt, and the inner lateral border of the internal one may be conspicuously raised (Podilymbus). The subcubical hypotarsus of the tarso-metatarsus in most all grebes is deeply once-grooved in the mid-longitudinal line behind; and in front of this groove it presents one complete cylindrical perforation (also for the passage of tendons) with a similar, though smaller, perforation upon either side of it, situated more posteriorly.

This is quite different from what we find in the loons (see Fig. 18, of the Plate). Of the distal trochleæ the middle one is the lowest on the shaft; the outer one next; while the inner one is very distinctly elevated. They are all more or less drawn towards the rear aspect of the bone. The hallux digit is feeble and flake-like, as is the small, free metatarsal to which it is attached. It is considerably elevated upon the shaft.

Generally, the podal joints show more or less compression, while the terminal or ungual ones are positively scale-like, and, as it were, greatly flattened. Usually, the basal phalanges are the longest, and the others in any toe gradually diminish in this particular proceeding towards the extremities. Their arrangement as to the number on each toe is upon the more common ornithic plan of 2, 3, 4, 5 to the 1–4 toes respectively.

THE SKELETON IN THE LOONS.

In all of its essential characters, the skull of the loons agrees with that of the grebes. In the present description I have chosen the skeletons of *Urinator imber* and *Urinator lumme*,—the first being the bird known all over the world as *the* loon, the second, also a largely cosmopolitan type, is the red-throated loon or diver. In the latter the superior osseous mandible is fashioned upon the same plan as we found it in the long-billed grebes; it differs principally in curving very gently upwards, a feature not present in the beak of *U. imber*. The culmen in both species is convex and evenly rounded. Loons have the cranio-facial region depressed, best seen in *U. imber*, where the sutures between the nasal processes of the premaxillary and the nasals remain more or less open throughout life.

All the Urinatoridæ are holorhinal, and the dentary process of the nasal dips downwards and forwards in a gentle curve, thus including the large and somewhat elliptical osseous nares. They are devoid of any osseous nasal septum. Each lacrymal articulates to a very limited extent with the corresponding frontal, and almost entirely with the outer margin of the nasal. The os uncinatum at the inferior apex of its descending limit, fuses with that bone, but the lacrymal does not reach down to the maxillary in *U. lumme*, although it often does so in *U. imber*. In many of the gulls this process is much shorter, and is bent backwards and often anchyloses with the pars plana; in the Urinatoridæ the pars plana is not ossified, and the meseth-moidal plate is thin, showing a raised welt at the usual site of the base of this wing where it occurs in other groups.

A large vacuity is seen in the middle of the interorbital septum, but the optic and other foramina usually retain their integrity. The track of the olfactory nerve is commonly roofed over for its posterior third or more by an extension of the bony wall which covers the anterior aspect of the rhinencephalon. This arrangement is not seen in a specimen of the skull of *Larus glaucus*, and its interorbital septum is thick and entire.

The quadrate has a long, plate-like, and upturned orbital proc-

ess, and two prominent facets upon its mandibular foot, at about the same level.

Regarding the skull of any of the Urinatoridæ from above, the most striking features are the deep, sharply-defined, supra-orbital glandular depressions. These are extensively perforated by minute foramina over their posterior halves, while a large irregular foramen occurs at each anterior end. Over the frontals they are separated by a thin crest of bone in the median line, while their posterior halves curve regularly outwards, to extend upon each roof-like post-frontal projection. In *U. imber* we find them giving rise to a raised superior orbital margin, connecting the lacrymal and the aforesaid post-frontal projections, as in Alca and Uria. In *Urinator lumme* this rim is sometimes incomplete. Fully as marked as these supraorbital depressions are the extraordinary crotaphyte fossæ. These are very broad antero-posteriorly, and strongly-marked throughout. On the top of the skull they are separated by a raised median line of bone, being the simple backward extension of that smooth central area of the vault, which has remained unmutilated by depressions. From this these fossæ sweep on either side in increasing depth downwards and forwards beneath the overhanging post-frontal roof and over the top of the external auditory wing.

In a specimen of *U. imber* belonging to the U. S. National Museum (No. 18256) I find the superficies of the superior orbital margins very much roughened. In the middle line there is also a "parietal foramen" at the hinder termination of a longitudinal gutter that extends as far forwards as the thin crest dividing the supraorbital glandular depressions.

Viewing the skull of the red-throated diver from behind we find that the large dome-like supra-occipital prominence is overlapped by these broad crotaphyte fossæ, and the median line separating them is extended directly backwards as far as the superior margin of the foramen magnum. This prominence is also transversely crossed about its middle by the raised crest that separates the crotaphyte fossæ from the occipital area. The plane of the foramen magnum is nearly vertical, and the reniform condyle projects directly backward from a thick-set

pedicle, its convex surface being inferior. We shall see further on that this posterior aspect of a diver's skull resembles much less the same view of the skull of any of the Laridæ than Alca does; indeed, the posterior view of the skull of the razor-bill very closely resembles a like view of the skull in several of the gulls.

On the under side of the skull of *Urinator lumme* we find the arrangement of the palate and other elements agreeing in all essential particulars with the gulls, auks, or guillemots; in other words, its structure is that of a typical cecomorph of Huxley's classification, so far as these parts are concerned.

In a well-cleaned skull the palatines can easily be traced to their anterior endings, and this is equally true of *U. imber*. Behind they are long and narrow, showing a double carination with a concavity dividing them. This is again divided by a transverse ridge near the middle of the body of each bone on its under side. The ascending processes of the palatines are embraced by the hinder ends of the vomer, and between them both rides the thin inferior edge of the rostrum. Anteriorly the vomer among the Urinatoridæ is more or less pointed, while above it is longitudinally grooved for its entire length, and the edges of this groove are well curled outwards.

The maxillo-palatines are thin concavo-convex plates raised above the horizontal portions of the maxillaries, and otherwise arranged as in the Alcidæ and Laridæ.

The posterior heads of the palatines are in contact, and form a groove between them above for the rostral bar of the presphenoid. They are embraced in a peculiar manner by the anterior ends of the pterygoids, which are fashioned like little two-toed feet to hold them, the larger claw being above and the smaller one below, the seizure being of such a nature as to limit the motion to a fore and aft one. Coues noticed this arrangement in the loon, and alludes to it in his memoir. The posterior end of each pterygoid is much enlarged and makes an extensive articulation with the quadrate of the corresponding side.

The foramen ovale opens laterally in the red-throated diver, and still more so in the loon, and the posterior wall of each orbit is marked by an outwardly concave, nearly vertical ridge, which

seems to limit the depression of the crotaphyte fossa upon that aspect on either side. Among these divers the mandible is very much alike.

It is shaped so as to be in harmony with the form of the superior one, being carried to a sharp point anteriorly. Opposite to the posterior ends of the dentary each ramal side is deep from above, downwards, and the vacuity found in other birds upon this surface is completely closed in by the mandibular elements of the vicinity — the splenial and dentary — principally the latter.

As among the Alcidæ, however, we find a large elliptical foramen in the surangular in most divers, but rather a small one in the loon in the same situation. Both the upper and lower ramal borders are rounded and the coranoid processes fairly well developed.

Viewed from above, we find the mandible to be V-shaped, with rather a short symphysis. The articulate facets for the quadrate are large and included in a squarish area in each mandibular end. Each angle is truncate from above, downwards and backwards, its emarginated lateral borders behind, enclosing a rather deep concavity, seen upon direct posterior aspect. Now the outer of these two borders on either ramal angle is produced upwards, forwards, and outwards as quite a prominent peg-like process. Thus I consider the angles of this mandible as being both truncate and recurved, and it is easy to conceive how by gradual steps this condition in the Urinatoridæ could be so modified as to have the truncation subordinated or even disappear, while the process became the feature of the mandibular angle, as in such a form as *Lunda cirrata*, wherein but little further change is required to produce the process as found in the Gallinæ. The mandible of *Larus glaucus* before me has no such process, and the parts that give rise to it are not present, the mandibular ends being reduced to their simple requirements for articulation with the quadrates.

The skull and mandible in the Urinatoridæ are non-pneumatic, though apparently not always so in *U. imber*.

I regret very much to find that the hyoid arches belonging to the skeletons of these divers in my hands have been unfortunately lost, and I am unable to say anything about their struc-

ture in these birds from personal investigation. But in *U. imber* it essentially agrees with what we found in the grebes.

A complete skeleton of *Urinator lumme* (No. 13,646 Smithsonian Collection) before me, has 43 vertebræ in its spinal column. Of these the *fourteenth* is the first to bear a pair of free ribs; the succeeding six movable vertebræ connect with the sternum by costal ribs; the next seventeen unite as a "sacrum" with the pelvic bones; then follow six free caudals and a pygostyle containing several more.

The dorsal ribs are broad, and bear large, freely articulated epipleural appendages. Two pairs of ribs also come off from the sacrum, and meet long, sweeping hæmapophyses, that reach the costal borders of the sternum. This specimen has also a "floating costal rib," which is very small and delicate. It is seen on both sides. The form of the skeleton of the thoracic parietes agrees to some extent with the shape it assumes in the Alcidæ, with its hinder ribs sweeping beneath the pelvis. This latter bone is of extraordinary form and dimensions in all of the Urinatoridæ, even excelling the grebes in some of its peculiarities. The anterior portion of an ilium is short and depressed in comparison with its extensive backward reach. The neural crest of the sacrum appears above the pelvic bones for its entire length, and posterior to the large elliptical ischiac foramen the ilium looks directly outwards, then outwards and upwards. A small prepubis is present, while the post-pubic element is long and slender, its posterior extremity, curving beneath the pelvis behind, is dilated and paddle-shaped. It nearly meets the fellow of the opposite side, where both are completed by an emargination of cartilage. It differs from the grebes in that it articulates with the postero-inferior angle of the ischium upon either side.

Five of the last caudal vertebræ, together with the pygostyle, are shown in side view in my above mentioned paper (*Jour. Anat. and Physiol*). The three first chevron bones there exhibited are freely articulated over the joints of the centra when they are present; the ultimate ones, however, become anchylosed to the under side of the rear vertebra in each case, the last one really forming the antero-inferior process of the pygostyle.

Coues in his examination of the skeleton in *Urinator imber*

found 13 vertebræ in the cervical portion of the spinal column, with nothing especially peculiar in their articulations,[1] and he says that although they "possess characters which most readily separate them from those of any other portion of the column, they yet differ greatly from each other, in different portions of the neck..... Beginning with the third vertebra, and proceeding backwards, we find that the length of the bodies increases successively to about the 8th or 9th, when it again decreases rapidly, so that the last one is not as long as the third. The body of the third is thin, being exceedingly compressed vertically; and coincidently with the lengthening of each one successively to the 8th or 9th, they grow wider, and comparatively not so deep vertically; those that follow, however, do not again grow more compressed as they shorten; but on the contrary become broader and broader, so that the last one is as wide as deep, and very stout and strong. With this widening, there is also, towards the posterior extremity of this portion of the spine, a very high development of the transverse processes of the anterior extremities of each vertebra. This is so considerable, that the width across these transverse processes much exceeds the length of the whole vertebra. These processes are also exceedingly stout, with several roughened eminences for muscular attachments; and the foramen for the vertebral artery, which their two roots form, is as large as the spinal canal itself. Now as we proceed up the neck to the head, these transverse processes project less and less from the bodies of the vertebræ, and become less robust and angular, at the same time that they are antero-posteriorly elongated; and possess regular lamelloid walls, so as to form rather canals than simple foramina for the artery."

"The 'styliform processes' or 'rudimentary ribs' appear to arise from the posterior aspects of the summits of each of the transverse processes, beginning with the third vertebra. They are directed backwards, exactly parallel with the axis of the

[1] Coues, E., The Osteology of the Colymbus torquatus, with notes on its Myology.— *Mem. Bost. Soc. Nat. Hist.*, i, pt. ii, Nov., 1866, pp. 131–172, fig. 2, pl. 5. This time-honored and excellent paper was also afterwards separately issued with a slight change in its title, but apparently without revision.

column, and, according to their length, form a more or less complete osseous covering and protection to the vertebral artery during its passage between any two contiguous foramina."

Then after describing the neural and hæmal spines of the "cervical vertebræ"; the axis and the atlas, Coues proceeds by saying that, "If we consider the *dorsal* as corresponding in number with the ribs, we should assign ten to this portion of the column. The last three ribs, however, correspond to vertebræ which are completely anchylosed to the sacrum as well as to the iliac bones, and at the same time they differ in several respects from the dorsal ribs proper. . . . ."

"The transverse processes of these [dorsal] vertebræ are as usual very broad, long, and thin; their posterior border concave, their anterior convex, and their postero-external angles prolonged backwards into a short 'styliform' process, more or less intimately connected with the next succeeding vertebra. The horizontal lamellæ of the transverse processes of the last four vertebræ are pierced by a quite large foramen."

"The superior spinous processes of the vertebræ are so long that they nearly touch each other by their anterior and posterior borders; only a slight space being left between them. They are quite regularly rectangular in shape, having straight, flat superior borders at right angles with the anterior and posterior borders. They are connected with each other by dense and strong ligaments, and probably become more or less completely anchylosed with age." He then carefully describes the *enormous* development of the hæmal spines of the dorsal vertebræ,—and although of much the same shape, the one for *U. lumme* (*Jour. Anat. and Physiol.*) gives but a feeble idea of their remarkable development in *Urinator imber*, the subject of the memoir from which I have been quoting. Among themselves the motion of the vertebræ during life in this dorsal region of the column is wonderfully restricted, and as I have shown above, in some grebes the dorsal vertebræ all fuse into one common piece.

Coues made out 15 vertebræ as being fused together in the pelvic sacrum; but in a specimen before me, after careful count, there appear to be sixteen. Marsh found but 14 in the sacrum of *Hesperornis regalis*.

From specimens at hand it would appear that in *Urinator lumme*, the ilia anchylose with the sacral vertebræ for the entire length of the sacrum, whereas in a specimen of *U. imber* before me (No. 18256, U. S. Nat. Mus.) fusion only exists opposite the acetabulæ and thence on anteriorly to the fore end, inclusive. In Hesperornis it was only opposite the acetabulæ that fusion took place.

As much alike as the pelves of *U. lumme* and *imber* are, there is still another interesting difference between them, for in the former the anterior ends of the ilia are seen to be quite obliquely truncated, — they are more or less rounded in the latter species. Marsh says of those bones in *Hesperornis regalis*, that "the anterior extremity of the ilium is thin, and rounded in outline" (*Odontornithes*, p. 69), but fundamentally the pelves of all these divers are much the same.

In describing the ribs in *Urinator imber*, Coues remarks (p. 144) that they "are ten in number. Of these nine articulate with the spine, and eight with the sternum. Seven only are dorsal ribs proper; the eighth and ninth being articulated with the sacral vertebræ posterior to the tip of the crista ilii, and the tenth being connected neither with the spine nor sternum. . . . ."

"As usual, the ribs consist of vertebral and sternal portions, movably articulated with each other. Both of these portions grow successively longer from before backwards; but the sternal portions much more rapidly than the vertebral. Thus while the sternal portion of the second rib is barely three fourths of an inch long, that of the seventh is fully three inches. The angle at the junction of these two portions, of course, varies with every stage of an inspiration and expiration; but at any given moment the angles become successively more acute from before backwards, — from the increasing length of the vertebral as well as the sternal portions. . . . ." The last rib differs from all the others in being unattached at either vertebral or sternal extremity. It consists merely of two extremely slender elastic bones, tapering to a fine point, somewhat larger and broader at their bases, where they are joined to each other. The sternal portion is longer than the vertebral. Close by the junction of the two, this sternal portion sends off from its posterior border

a small, slight process, which curves directly outwards and forwards, lying parallel with the posterior border of the rib, which it joins again about an inch from its origin, — leaving a space filled up only by membrane. This may very possibly be regarded as the rudiment of an eleventh rib, of which the vertebral portion is wholly wanting. It is sometimes entirely obsolete."

"The latter ribs project so far backwards, that the thoracic parietes are prolonged some distance behind the acetabula, and consequently the femur in its normal position lies directly over the last three or four ribs, and moves backwards and forwards upon them. The angle of the last rib reaches within less than two inches of the posterior extremity of the elongated obturator foramen" (*loc. cit.* pp. 145, 146).

Marsh says that "the ribs of *Hesperornis* present no marked features to distinguish them from those of modern birds. They are composed of dense bone, but some of them contain irregular cavities. The articulated vertebral ribs of *Hesperornis regalis* are nine in number, on each side. The first three of these were attached to the last three cervical vertebræ, and had their distal ends free. The remaining six are all well developed ribs, which were connected by means of the sternal ribs with the sternum" (*loc. cit.* p. 63).

In comparing Marsh's figures of the sterna of *Hesperornis regalis* and *Hesperornis crassipes*, I find upon either costal border of the sternum of the first-named species but *four* facets for articulation with the costal ribs, whereas in the latter form there are *five* represented; and from this I am led to believe that there was quite as much, if not more, variation in this matter of ribs among those now long extinct types as there is among their existing affines. (Compare Marsh's Plates vi and vii, Figs. 1, 2, and 1, 2 respectively.)

Grebes, loons, and the great toothed divers of the Cretaceous period all vary in this particular. And sometimes, too, as we know, they are apt not to agree even in the number of facettes on the costal border of the same sternum. Frequently the number varies for the genus Urinator now under consideration, of the family Urinatoridæ, — sometimes in the same species, but more often among different species.

A clavicle of the pectoral arch has a broad head, but is as thin as a knife-blade, the outer aspect of which, when articulated, simply rests against the summit of the coracoid, while its posterior end rides over the head of the scapula. This expanded part of the clavicle rapidly contracts in width as it descends, until it becomes quite rod-like, square on section, to curve abruptly towards the sternum, where it unites with the fellow of the opposite side to support in the median line rather a long, peg-like hypocleidium. Viewed from in front, the furcula is a wide U-shaped bone, with its lower arc curved more than usually upwards. In common with other bones of the arch, it is non-pneumatic.

The lower part of a coracoid is much expanded laterally, with smooth and evenly concave articular lower margin for the sternal groove. As in some of the auks, the lower lateral margin of the bone develops a prominent upturned laminated process. The shaft of the coracoid is transversely elliptical on section, and its scapular process may, or may not descend, upon its inner side, sufficiently far as to be pierced by the foramen, which likewise occurs in the Alcidæ. The head rears to a considerable extent above the glenoid cavity, and its tuberous summit curls over towards the median plane.

Larus glaucus possesses a coracoid that has the foramen in the scapular process, as well as the laminated externo-lateral apophysis as in Urinator, but its furcula resembles that bone as we find it in the auks and guillemots.

The scapula in the red-throated diver is short, and doubly truncate behind. Its curvature may be quite abrupt just beyond the head in some specimens. This latter is transversely narrow, and thickened from above, downwards; it occupies the entire upper margin of the scapular process of the coracoid.

In the Yellow-billed loon (*U. adamsii*), when the pectoral arch is articulated *in situ*, if the line of the long axis of the coracoid were produced downwards, it would cut the lower margin of the keel of the sternum at the junction of its middle and anterior thirds; the scapulæ are much tilted upwards, and the aborted hypocleidium of the furcula is over the tip of the carinal angle and separated from it by about a centimetre.

In *Urinator imber* the U is by no means as broad as it is in *U. lumme*, the upper expanded parts are even still thinner, and relatively somewhat larger, and finally, it totally lacks the hypocleidium. All this agrees with the os furcula of the loon, the skeleton of which Coues described (*loc. cit.* p. 148).

The coracoid of *U. imber* very closely agrees with that bone as we find it in *U. lumme*, but the foramen that pierces the scapular process in *imber*, is a constant feature in that species. The scapulæ of these two divers are essentially quite alike, except in point of size. A point to be noticed in this latter bone, is the fact that the head and neck is bent at a rounded angle, with greater or less abruptness with the continuity of the blade of the bone. This flexure (*U. lumme*, Spec. No. 13646 coll. U. S. Nat. Museum) is greater in one scapula than it is in the other; the angle being more acute upon the left side. It is very open in other specimens.

In *Hesperornis regalis* the clavicles in the adult did not fuse with each other at the middle point below, simply articulating at the point of contact. This is the condition of those bones in the very young of *Urinator imber*, an embryonic condition, as it were, that persists throughout life in the great extinct ancestor of our loon.

Comparatively speaking, in all the loons, we find the sternum to be a very large bone. It is twice as long as it is broad, and it has great triangular costal processes. An extensive oval notch on either side of the keel behind gives rise to lateral xiphoidal processes, while the mid-portion, shaped like a shield or an escutcheon, extends considerably more posteriorly, and does not entirely ossify around its hinder border until late in life. It may be pierced by a few foramina, where ossification has not been quite thorough. This part of the sternum is unkeeled, the keel at the best being very low, but with prominent and projecting carinal angle in front.

As I have said above, the usual number of facets upon either costal border is eight; there may, however, be but seven. The manubrium is broadly wedge-shaped and nearly aborted; its triangular, anterior face is slightly concaved. Costal grooves are long and deep, but relatively, not as deep as they are in the

grebes. They almost meet each other in the middle line, the interval between them being less than the width of manubrial base. On its thoracic aspect the bone is concaved, being most so anteriorly, and gradually shallowing as we approach its hinder part. Both this surface and the ventral one are very smooth. Upon the latter the 'pectoral muscular line' extends from the mid point of the lower lip of the outer third of the costal groove obliquely to the carina meeting it at the juncture of its anterior and middle thirds. In *U. imber* the bone averages 20 centimetres for its greatest length, and 8.5 cms. for its greatest breadth; — the last measurement being taken across the lateral xiphoidal processes. Though very light and elegantly proportioned the base is absolutely non-pneumatic throughout the superfamily. Its form is well shown in the sternum of *Urinator lumme* (Spec. No. 16628 of the U. S. Nat. Mus. Coll. ♀) but its pattern may vary considerably, being remarkably narrow and long in some individuals. When thus fashioned it reminds one very much of the sternum in certain of the auks. But among some water birds skeletal characters crop out very strangely sometimes, and even to the casual observer the sternum of an albatross, a cormorant, Plotus, a fulmar, and a grebe all more or less closely resemble each other upon a direct pectoral view, and to a less extent in several of those forms, when viewed from the side.

In concluding his account of the sternum of the loon, Coues says: "Viewing, now, the sternum as a whole, we have to notice how great an extent of surface is secured with a trifling increase of weight. Posteriorly, this is attained by means of the great lateral projection of the apophyses, as well as by their length, and by the breadth and projection backwards of the thin, almost cartilaginous xiphoid. Anteriorly, where the sternum is not so wide, the deficiency is atoned for by the great depth of the keel, and its projection forward; at the same time the outline of the crest of the keel is such that when the inequalities of the bone is all filled up with muscular tissue the resulting surface becomes flat, and broad as well as long, affording the best possible outline for contact with the water." (*loc. cit.* pp. 147, 148.)

According to Marsh "The sternum in *Hesperornis* somewhat

resembles in general form the corresponding bone in the genus *Uria*, but in other respects is more like that in the *Ratitæ*. It is thin and weak, and entirely without a keel. It is expanded in front, especially between the costal processes, and has two deep grooves for the reception of the coracoids. These grooves are placed obliquely, converging anteriorly, and are widely separated from each other. The sternum has a rounded mesial projection in front, which is somewhat thickened, but there is no true manubrium." .... "The sides of the sternum in *Hesperornis* are concave in outline, and in *Hesperornis regalis*, there are four articular projections on each side for the attachment of sternal ribs. These processes are all on the anterior half of the sternum. Behind these the lateral margins are nearly parallel. The posterior end of the sternum is quite thin, and had two shallow emarginations. In *Hesperornis crassipes* the sternum had five articular faces on each side for the sternal ribs. The posterior margin in the same species is less excavated than in *Hesperornis regalis*." (*Ordontornithes*. p. 60.)

If you will refer to Plate VII of Marsh's work, from which I have just been quoting, and examine Fig. 3 of the sternum of *Hesperornis crassipes*, it will not be difficult to believe that perhaps the sternum of that species had lateral xiphoidal processes something like those found in *Colymbus cristatus*. In the specimen they look very much as though they had been broken off, an accident very likely to occur in the sternum of a fossil bird, and frequently seen even in the sterna of our existing birds in the collections in the museums. The xiphoidal part of the sternum was cleft by a shallow triangular notch, in *Hesperornis crassipes*, precisely as we find it now in many of our existing grebes.

THE PECTORAL LIMB IN THE URINATORIDÆ.

All the bones of the upper extremity are non-pneumatic in this family. They are heavy, and when simply cleaned in the rough, they soon become dark and the oily substances contained in their cavities ooze out upon their outer surface in no inconsiderable amount.

The palmar aspect of the proximal end of the humerus has a large subcircular elevation upon it that is quite characteristic. This projects in such a manner that upon the reverse side it is seen extending beyond the border of the bone, near the shallow, pseudo-pneumatic fossa.

The radial crest from its size and length is more than usually conspicuous; its free border is a long convexity, and this plate-like process is carried well down the shaft, occupying fully one-third of its length. Below it, the shaft for its middle third becomes subcylindrical, showing a large nutrient foramen upon its ulnar aspect.

The distal end of the bone is not spread much in a transverse direction, but otherwise rather bulky. Two wide and shallow furrows mark it on the anconal side for the passage of tendons, and a large oblique and ulnar trochlea stand out upon the other. The ectocondyloid process is barely noticeable.

The radius is straight, and the major part of its shaft nearly cylindrical; its articular ends present the characters of the bone as seen in the majority of the class. When articulated, these alone meet the ulna, giving rise to a long, narrow, interosseous space. Towards this the larger bone of the antibrachium presents a concave border of a moderate degree of curvature. Its shaft, too, is quite cylindrical, and faintly shows the row of papillæ for the quills of the secondaries. It develops in a transverse direction not an inconsiderable ledge at its distal end, upon which the expanded end of the radius rests in articulation.

The carpus is composed of the two elements found in most birds; they are here simply somewhat modified in form for the family, and to accommodate themselves to the shape of the other bones with which they come in contact. They in turn having their own specific cast.

One of the first things that forces itself upon our attention in examining the skeleton of the hand of one of these divers is the unusual length (comparatively speaking) of the metacarpals. Of these, the one for the pollex digit is of an extraordinary length; much more than a third the length of the index one, and co-ossified with it in the usual manner.

I do not recall an instance among birds where the comparative

lengths of these two metacarpals is anything like it. The proximal phalanx of the pollex is also long and compressed. It bears a claw upon its extremity. Both of the other metacarpals are long and very straight, allowing but a narrow interval to exist between them.

The blade of the proximal phalanx of the index is meagre, being flat anconad and faintly pitted upon the opposite side. Its distal joint also bears a claw.

The phalanx of the middle finger is fully half as long as the expanded one of index alongside of which it lies.

These observations upon the pectoral limit of the Urinatoridæ have been jotted down during my examination of this part of the skeleton in a specimen of *U. lumme*, and in it I find the skeleton of the manus, just described, equalling in length the bones of the antibrachium.

The humerus in this diver has a length of about 14.5 cm.; the radius 11.4; the ulna 11.65; manus 11.8, of which latter the carpo-metacarpus claims 7.5 cm. From this it is seen that when the skeleton of the limb is in a position of rest and closed alongside the chest, the humerus projects beyond the bones of the anti-brachium for some little distance. This is not the case among the Laridæ, whereas it agrees with *Alca torda*, Uria, and, I expect, the Alcidæ generally.

The Pelvic Limb in the Urinatoridæ.

The skeleton of the pelvic limb in the Urinatoridæ is a very interesting structure, and highly characteristic of the family.

Coues has described its mechanism and structure in *U. imber* in his memoir before alluded to, and I will here record a few observations that I have made upon this limb as found in *Urinator lumme*.

The femur is short and thick, being about as long as the cnemial process of the tibio-tarsus above the articulation. Its short shaft is somewhat cylindrical near the middle, bowed to the front, and scarred in many places by tuberous projections for muscular insertion. The head is large and globular, sessile, and deeply marked by the pit for the ligamentum teres. Dis-

tally, it is much expanded in a transverse direction, the inner condyle being small and elevated, the outer one being very large, strongly cleft behind for the fibular head, much the lower of the two, and separated from its companion in front by a deep rotular fossa.

The patella of the red-throated diver and other loons is generally considered to be the flake-like bone articulating at the posterior base of the cnemial process of the tibia. Its form and exact position I have given in my paper on the patellæ in birds referred to in the second paragraph of the present paper. This illustration also presents the outer aspect of the femur, tibio-tarsus, and fibula; the latter two for their proximal two-thirds only.

Nothing could be more interesting than the form assumed by the tibio-tarsus of this diver. Its cnemial process is enormously produced, having a deep, longitudinal concavity between its pro- and ecto-cnemial ridges in front, and the two sides meeting in a median ridge behind. The pro-cnemial ridge is carried down as a wing for some distance on the side of the shaft. This latter is somewhat flattened from before backwards for its entire length, but better marked in this particular at its distal extremity, just before we arrive at the condyles, where also it is marked by the broad, shallow tendinal groove. This is bridged over by the usual bony span for the deep extensors.

The condyles are very prominent in front, but approach each other as low, sharp ridges behind. Coues found the fibula in the loon, "for an inch or so, quite separate from the tibia; is then united with it for some distance, becomes again distinct for about an inch, and then finally merges as a slender spiculum into the side of the tibia, rather more than an inch above the joint. A slight crest, however, gives an indication of it, which can be traced quite to the external malleolus of the tibia." This description agrees with one of the specimens of *U. lumme*, but in another it is carried down distinct and prominent to terminate in a well-formed malleolus upon the lower antero-lateral aspect of the shaft. The lower portion is anchylosed with the tibio-tarsus, but could, with but little difficulty, be separated from it with a good sharp knife. In other words we find specimens of *Urinator lumme* wherein the fibula is complete.

Four figures of the Plate illustrating the present paper are devoted to the extraordinary tarso-metatarsus of the Urinatoridæ as seen in *U. lumme*. These give various aspects of the bone, and distinctly show all the characters it possesses. Chief among these is the great amount of lateral compression of the shaft and trochlear end. The former is grooved both in front and behind for its entire length, forming a guide as well as a harbor for the passage of tendons.

The hypotarsus is very large, it being composed of a posterior arcade of bone with three distinct foramina piercing its substance in front of it. Occupying a position above the base of the mid-trochlea, the inner one of these three compressed protuberances projects the most posteriorly. The remaining two are separated by a cleft, which is continued above by a groove on the anterior surface, to be pierced obliquely from above, downwards, by the usual arterial foramen. The mid-trochlea is the lowest of all three, and rather the most anterior. They are all strongly marked by median grooves intended for the corresponding surface on each proximal phalanx of the digits.

A scale-like first metatarsal is suspended by a ligament attached to its entire anterior free border, to the inner inferior posterior margin of the shaft of the bone. It supports a feebly developed phalanx and claw representing the hallux digit. As for the three anterior toes, they are composed upon the usual formula for the number of joints as found in this member in the majority of the class. All of the ungual phalanges are in this diver flat and scale-like.

The proportionate lengths of these joints in the skeleton of the pes are shown in the following measurements: — Hallux joint has a length of but 1.1 centimeters, its claw but 0.5; the proximal phalanx of the inside toe measures 4.0 centimeters, the next joint 2.1, and its claw 0.95. The proximal joint of the middle toe 3.6, next joint 2.0, next 1.8, the claw 0.9; finally the proximal joint of the outside toe 2.8, next 1.6, next 1.4, next 1.8, and the claw 0.85.

Aside from the osteology and other interesting points of structure in the pelvic limb of red-throated diver, a notable feature is to be noticed in the great number of fibrous loops

attached to the long bones at a number of points, which serve to surround and guide the various tendons on their passage to the toes and prevent them from slipping from their places as they pass these narrow bones, when the limb is brought into vigorous action.

D'Arcy Thompson in his very excellent memoir "On the Systematic Position of Hesperornis" in contrasting the characters presented in the pelvic limb of *H. regalis* with the corresponding ones as found in the hind limb of *U. imber* says of the former that "Firstly, the extreme shortness of the femur is a very Colymbine feature; that bone is in *Colymbus* [*Urinator*] and *Hesperornis* about one-quarter the length of the ilium; whereas in the Ratites, except in exceptional cases, such as *Dinornis elephantopus*, the two bones are nearly of equal length. Secondly, and of greater importance, the patella, which, small and double in the Ostrich, is rudimentary or absent altogether in the other Ratites, is of immense size and peculiar shape in *Hesperornis*. In this bird it is a long trihedral pyramid, pointed at its superior extremity, concave on its outer surface, bearing at its lower extremity special and separate articular surfaces for the tibia and femur, and lying in a line with the long axis of the femur. Except that it is perforated for the tendon of the *ambiens* muscle (as in the Gannet), it is extremely like the patella of the Grebe, and practically identical with that of *Colymbus* [*Urinator*], except that in this latter it is fused with the upper extremity of the tibia. The existence of a small additional sesamoid in the knee-joint of *Colymbus* [Urinator] (Owen, *Comp. Anat. II.*, p. 83) does not invalidate the homology here adopted of the long 'rotular process of the tibia' with the patella." (pp. 11, 12.)

If Thompson means by this that in the loons (Urinator) the patella originally was separate as it now is in the grebes and held the same relative position to an elongated rotular process of the tibio-tarsus, as in the latter birds, and that since, in the loons, such a patella has come to be fused with the aforesaid process of the tibio-tarsus, the present writer is inclined to agree with him, although he formerly held the opinion that the small flake-like bone described by Owen was the only patella possessed

by the Urinatoridæ. Further along I shall refer to this matter again.

The study of the patella in birds is a very interesting, not to say, an important one, and, as has been noted above, as long ago as 1884 the writer published an article in the *Proceedings of the United States National Museum* on the subject (Vol. VII, pp. 324–331) in which was figured the patellæ of certain penguins, mergansers, gannets, grebes, divers, fulmars, Hesperornis, crows and cormorants; and to that article the reader is referred for information touching what has just been said above.

There can be no question about the existence of the patella in the grebes, nor in Hesperornis, nor in the cormorants, but as I have already shown, morphologists are not thoroughly agreed upon the nature of the flake-like sesamoid found at the knee in a loon, nor homologically speaking, its significance. Granted that a large patella in the Urinatoridæ has fused with the long cnemial process of the tibio-tarsus, then it would hardly appear that the small flake-like bone in the tendon of the extensor femoris muscle should be considered a patella at all, although in the matter of position it agrees with that sesamoid as it is found in all birds that possess it. It would hardly seem reasonable that Urinator had *two* patellæ at either knee-joint, and such very dissimilar ones. In my opinion the last word upon this subject remains yet to be said. The embryology of the Urinatoridæ, as well as the morphology of the structures involved in specimens of nestlings and subadults of the species in all stages of their growth, requires investigating.

In the *Journal of Anatomy* (London) (Vol. XXIV, January, 1890, and other volumes) I published a "Brief Summary of the Principal Osteological Characters of the Urinatoridæ" to which I refer the reader for further details regarding the osteology of the grebes and loons.

It now remains for me to compare the principal osteological characters of the loons and the grebes. These may be conveniently arranged for reference in the following manner:—

A FEW OF THE OSTEOLOGICAL CHARACTERS WHICH DISTINGUISHED THE PODICIPOIDEA AND THE URINATOROIDEA.

Podicipoidea.— Pars plana ossifies.

Urinatoroidea.— Pars plana does not ossify.

Podicipoidea.— Supra-orbital glandular fossæ but faintly mark the skull.

Urinatoroidea.— Supra-orbital glandular fossæ deeply mark the skull, being within the superior border of the orbit and separated from each other mesially by a *thin*, longitudinal crest of bone.

Podicipoidea.— Twenty-four (24) or more dorso-cervical vertebræ.

Urinatoroidea.—Twenty (20) dorso-cervical vertebræ. Not more.

Podicipoidea.— Sternum *short* and broad, with the lateral xiphoidal processes extending more posteriorly than the mid-xiphoidal piece, which latter is triangularly notched in the middle line.

Urinatoroidea.— Sternum nearly twice as long as it is broad, with the lateral xiphoidal processes not extending more posteriorly than the mid-xiphoidal piece, which latter is unnotched and rounded off posteriorly.

Podicipoidea.— Posterior free extremities of *os furcula* very narrow and pointed.

Urinatoroidea.— Posterior free extremities of *os furcula* very broad, laterally compressed, and apices bluntly rounded off.

Podicipoidea.— Posteriorly the ischium does not articulate with the superior margin of the very long post-pubic style, anterior to its free end; and the latter is not perceptibly dilated.

Urinatoroidea. — Posteriorly the ischium does articulate with the superior margin of the very long post-pubic style, anterior to its free end; and the latter is considerably dilated and paddle-shaped.

Podicipoidea. — Pollex metacarpal short.

Urinatoroidea. — Pollex metacarpal remarkably long.

Podicipoidea. — Possessed of a large patella, co-existing with an elongated cnemial process of the tibio-tarsus.

Urinatoroidea. — Possessed only of a very small, flake-like sesamoid, which occurs in the tendon of the extensor femoris muscle at its insertion; and probably the true patella has coössified in the adult with the elongated cnemial process of the tibio-tarsus.

Affinities of the Pygopodes.

Taken in connection with many other good characters presented in the structure of grebes and loons, we must believe that the differentiating osteological ones just given above, point to the fact that the relationship now existing between these two well-defined groups of birds can best be appreciated by creating for them a superfamily in each case. To this end I consider the grebes to compose the superfamily Podicipoidea, and the loons the superfamily Urinatoroidea.

In 1884 (*Proc. U. S. Nat. Mus.*, vol. vii, p. 331) I considered the representatives of the extinct genus of cretaceous toothed birds, Hesperornis to be "powerful divers" and the "ancient ancestors" of our present existing grebes and loons. Essentially, this still remains my opinion; and, at a later day, after carefully comparing the osteological characters of the Podicipoidea and Urinatoroidea with the corresponding ones in the skeleton of *Hesperornis regalis* and *H. crassipes* as given by Marsh, I again said that the result of those investigations "convince me of the fact that, however widely separated now, our existing loons and grebes are derived from the same ancestral stock to which *H. regalis* belonged" (*Jour. of Anat.* London, Jan., 1890, p. 169).

Our existing grebes and loons then are derived from, or are the descendants of great toothed divers long since extinct. Possibly the Hesperornithidæ were an offshoot family of a superfamily,— the Hesperornithoidea, the latter the more typical of these extinct divers, and from them our present Pygopodes were derived, but we yet lack the necessary material to place such a question beyond dispute. From a consideration of the osteolog-

ical characters I consider the Podicipoidea to be an earlier offshoot of the pygopodine stem than the Urinatoroidea, and more nearly related to Hesperornis than are the latter birds. The morphology of the pelvis and the pelvic limb, as well as certain characters in the skull and trunk skeleton, point, I think, in favor of this view.

No doubt but what the Hesperornithidæ were in their turn derived from still more ancient ancestors possessed of the power of flight, and in the ages to come our present-day Pygopodes, if it be their fate to have descendants, direct or indirect, those descendants may in turn again become flightless forms through a gradual loss of their pectoral limbs.

So far as the affinities of the Pygopodes are concerned with other groups of existing birds, we shall see in other memoirs I propose to publish on the subject that they present a number of osteological characters exhibited in common with the Alcæ and the Longipennes.

EXPLANATION OF THE PLATE.

(Limb-bones of Water Birds: all drawn by the author, about five-sixths natural size.)

FIG. 1. Right femur of *Urinator lumme*; anterior surface.

FIG. 2. Right femur of *Urinator lumme*; inner surface.

FIG. 3. Right tarso-metatarsus of *Larus delawarensis*; anterior aspect.

FIG. 4. Right tarso-metatarsus of *Larus delawarensis*; distal extremity viewed from below.

FIG. 5. Right tarso-metatarsus of *Larus delawarensis*; proximal extremity viewed directly from above; nat. size. Figs. 3, 4, and 5, all from the same specimen.

FIG. 6. Right tarso-metatarsus of *Hæmatopus bachmani*; anterior aspect.

FIG. 7. Direct view from below, distal extremity, same bone as in Fig. 6.

FIG. 8. Direct view from above, proximal extremity of the right tarso-metatarsus of *H. bachmani*, same bone as shown in Figs. 6 and 7.

FIG. 9. The same bone as in last figure seen upon the inner aspect of its distal extremity. (All from specimen 13636, coll. U. S. Nat. Mus.)

FIG. 10. Right tarso-metatarsus of *Chiornis minor*, anterior aspect. (From Dr. Kidder's type specimen.)

FIG. 11. Direct view from above, proximal extremity, same bone as in last figure.

FIG. 12. Direct view from below of the distal extremity of the right tarso-metatarsus of *Chiornis minor*.

FIG. 13. Right femur of *Chiornis minor*; anterior surface.

FIG. 14. Right femur of *Hæmatopus backmani*; anterior surface. (No. 13636, coll. U. S. Nat. Mus.)

FIG. 15. Right femur of *Larus delawarensis*; anterior surface.

FIG. 16. Right tarso-metatarsus of *Urinator lumme*; inner surface.

FIG. 17. Right tarso-metatarsus of *Urinator lumme*; anterior surface. Same specimen.

FIG. 18. Direct view from above, proximal extremity, of the same bone (*U. lumme*).

FIG. 19. Right femur of *Urinator lumme*; posterior surface.

FIG. 20. Direct view from below of the right tarso-metatarsus of *Urinator lumme*, distal extremity.

FIG. 21. Right tibio-tarsus and fibula of *Urinator lumme*; anterior aspect.

FIG. 22. Right tibio-tarsus of *Chiornis minor*.

FIG. 23. Right tibio-tarsus and fibula of *Hæmatopus backmani*; anterior surface. (No. 13636, Coll. U. S. Nat. Mus.)

FIG. 24. Right tibio-tarsus and fibula of *Larus delawarensis*; anterior surface. From the same skeleton that furnished bones for the other figures given above.

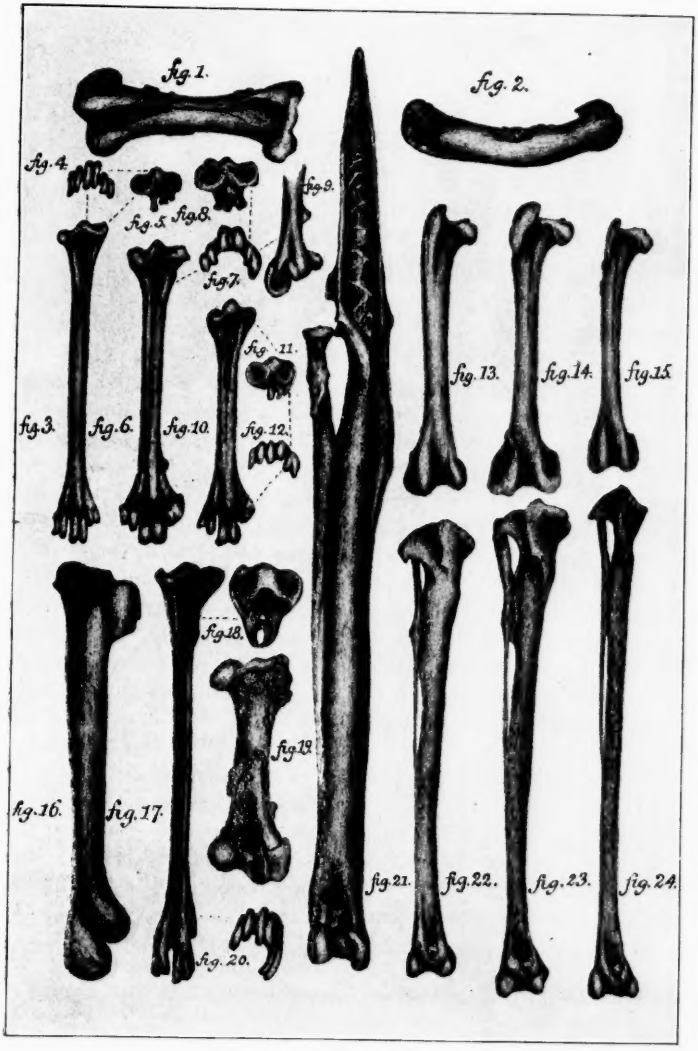
fig. 1.
fig. 2.
fig. 4.
fig. 5.
fig. 8.
fig. 9.
fig. 7.
fig. 11.
fig. 12.
fig. 3.
fig. 6.
fig. 10.
fig. 13.
fig. 14.
fig. 15.
fig. 18.
fig. 19.
fig. 16.
fig. 17.
fig. 20.
fig. 21.
fig. 22.
fig. 23.
fig. 24.

THE ERUPTION OF MOUNT PELÉE, 1851.[1]

Translated from the French of LePrieur, Peyraud and Rufz by

T. A. JAGGAR, JR.

Translator's Note.

The following account of the eruption of 1851 is a valuable geographical record for students of the recent volcanic happenings in Martinique, and the only printed copy of the original report known to the writer is in the library at Fort de France. The region described as the seat of activity in 1851, a gorge adjacent to that containing the Etang Sec, is practically identical with the site of the crater of 1902, or parts of it, and the very careful description of earlier conditions there throws light on many of the phenomena of the later eruptions.

The investigating commission of 1851 report (1) abundant *pumice* in the old rocks of the mountain, (2) no activity at the summit lake, (3) unusual amount of water in the Etang Sec, (4) entire absence of lava or incandescent material, (5) fragments of diorite ejected, (6) hot waters, steam and dry rock-dust from the vents, (7) a local tornado, (8) sulphuretted hydrogen, (9) a buzzing noise or intermittent detonations. In a very suggestive footnote they comment on the superficial quality of the explosions, and although not themselves geologists, they conclude that Mount Pelée has never ejected molten lava in any considerable amount, but has always belonged rather to the cinder-cone type of volcanoes. There are, in fact, some ancient lava flows and intrusive sheets, but they are rare, the tuffs and agglomerates everywhere predominating.

No attempt has been made to eliminate errors in the original account. There are some geological and chemical phrases that are

[1] Official Report of 1851.— The manuscript was apparently drafted by Dr. Rufz. The translator obtained access to the printed copy of this report, kept in the library at Fort de France. Eruption du Volcan de la Montagne-Pelée. Pub. in 1851. E. Ruella & Ch. Arnand. Imprimeurs du Government, Rue du Bord de Mer, 94. République Française.

antiquated and obviously inaccurate. The same is true of the opening sentence — there is certainly good historic evidence of the activity of Pelée before 1851. The notation for magnetic directions is obscure, and in such cases the original symbols are reproduced in the footnote. Making due allowance for trifling inaccuracies, the report as a whole is the most complete and scientific record extant of the topographic details of the southern slope of Pelée prior to the eruptions of 1902–03.

October, 1903.

THE OFFICIAL REPORT, 1851.

A tradition without historical foundation records Mt. Pelée to be a volcano. The conical form, the crater lake, the pumiceous soil, all fostered this supposition. It was known also that in one of the gorges there was sulphur, and the inhabitants living near called this the Soufrière. The druggist Peyraud made a scientific excursion there in 1838[1] and brought back stalactites of pure sulphur attached to the leaves of a tree.

[1] Letter to the "Directeur de l'intérieur," by Peyraud: —

Monsieur le Directeur général.

Jài l'honneu de vous addresser un petit flacon contenant de l'eau que j'ai rapportée de la source minérale qui se trouve sur les terres de M. Huc, à la naissance de la Rivière Claire. Je dois vous observer que cette eau que l'on màvait dit être à 60° Reaumur, nèst dans ce moment qu'à 16°, et l'air ambiant à 18°. J'y joins un échantillon de la matière jaune qui tapisse les bords du morne d'ou cette eau découle, puis un morceau de bois recouvert d'un mousse qui répand une forte odeur de marée. Ce bois a été recueilli à quelques pieds au-dessus de la source minérale, un peu à gauche en faisant face à la montagne. Je vais m'occuper de l'analyse de cette eau et m'empresserai de vous eu faire connaître le résultat.

Pour vous donner une idée de la quantité de gaz hydrogène sulfuré qui se dégage dans les environs de la source, je vous envoie un porte-crayon en argent que je portais sur moi lors de mon excursion. Il est à regretter que la nature ait placé cette eau dans un endroit ne permettant pas d'y former un établissement qui aurait été bien avantageux pour la colonie. Plus tard je ferai en sorte de vous addresser le plan de l'endroit où se trouve la source. Si vous désirez une plus grande quantité d'eau je me ferai un vrai plaisir de vous en faire puiser, que je renfermerai dans les flacons à l'émeri afin d'éviter la perte du gaz.

Je compte aller, dans quelques jours, parcourir la route de la Trinité afin de visiter l'endroit qui répand une odeur sulfureuse et vous rendrai compte immédiatement du résultat de mes recherches.

Je suis avec respect, Monsieur le Directeur général.

Votre tres humble serviteur,

Saint Pierre, le 20 Mai, 1838. P. PEYRAUD.

Recently the inhabitants of the Prêcheur heights have complained of a strong sulphurous odor. Some of them have visited the Soufrière and report a fuming hole which has appeared, the vapors mixing with the clouds and thus being imperceptible to sight at a distance. On the 3rd of August the patrolman Carbonel brought in a partridge found dead near the new opening, and he said there were many others, that all the birds dropped dead when they flew over the fatal cavity. Like the Avernus of the Ancients,

> Quam super haud ullæ potevant impune volantes
> Tendere eter pennis: Talis sese halitus atris
> Faucibus effundeus supera ad convexa ferebat:
> Unde locum Graii dixerunt nomine Avernon.
>
> *Virgil.*

This year (1851) from the 10th of May, there were no earthquakes in Martinique, but Guadeloupe had many of them and was in continual fear. August 5, St. Pierre was peaceful; the weather had been fine. Towards 11 p. m. a dull, distant sinister noise began, like thunder; it was mistaken for thunder, or for the roar of the river in flood. The noise increased, waked many people and caused alarm.

I was in my villa of Fonds Canonville, very near the source of the sounds. I thought it was thunder, but was astonished at its continuance; I heard the workmen call me from without. They shouted "Do you not hear that noise?" I answered, "Yes, it is thunder!" "No, it is the Soufrière." I rose and looked towards Mt. Pelée, but could see nothing: the noise continued. The rest of the night was passed in great anxiety, and torches were seen indicating the flight of many people. No one knew anything definite and the answer to all questions was, "C'est la Soufrière qui bout!"

St. Pierre was equally frightened. In the morning roofs, pavements, leaves of trees, all were covered by a thin layer of grayish cinders, which made the town look like a European city covered by the white frost of the early days of autumn.

These ashes covered the country between the city and Mt. Pelée, covered Morne Rouge, and extended to Carbet. The

stream called the Rivière Blanche, because of the color of its water (caused, like the "yellow baths" of Guadeloupe, probably, by the presence of an iron hydrate) became black, charged with ashes or mud, and this coloration of the water could be seen far out to sea, as in time of flood.

The spirit of the city was an anxious curiosity, dissimulating, according to the light-hearted spirit of the country, under many jests. A few brave spirits made a reconnaissance of the mountain, and from their description the first accounts were published in the "Courrier de la Martinique" and in "Les Antilles."

The government appointed an investigating commission; Le Prieur, chief Pharmacist of the colonial hospitals, who had already made several explorations in Guiana: Dr. Rufz, and pharmacist Peyraud. The present document is the report of this commission.

The general aspect of La Montagne Pelée, seen from St. Pierre, is that of a great cone, from whose summit descend sharp spurs down to its base, these spurs being separated by an equal number of gorges or valleys. It resembles the cone formed by a pleated filter paper. In order to reach the summit of the mountain it is necessary to follow one of the spurs, for the valleys are often precipitous gorges. On August 28, we took what is considered the most direct route, by way of the sugar plantation "Rivière Blanche," near the farm Paviot, and came out at the habitation Ruffin. Ruffin is a farm 1½ hours horseback from St. Pierre, 551 meters above the sea. We slept there: 7 a. m. the morning of Aug. 29, the thermometer marked in air 23° Centigrade and 22.5° in the earth. At St. Pierre at this hour, 27° or 28°. We descended by a zigzag path to the bottom of the ravine of the Riviere Claire. This path is cut in "*pumites*," or local pumice stones which are white and friable, in little fragments. The Rivière Claire is so-called by way of contrast to the Rivière Blanche. The latter, whose waters are always milky, comes from one of the creases in the mountain separated from the Rivière Claire by a steep spur: both flow separately above, but unite below, and continue to the sea under the name of the Rivière Blanche. It appears that now the Rivière Claire receives the volcanic mud and blackens the

Rivière Blanche, no longer deserving its name of "clear." At the bottom of the ravine where we were, the Rivière Claire forms a cascade 2 or 3 meters high: it is only a brook that one can easily jump over. Its banks were covered with from 15 to 20 centimeters of mud. The water has ceased to be drinkable.

After having crossed the bed of the Rivière Claire, it became necessary to climb the opposite slope which is a very abrupt escarpment, where the first explorers had to construct a path, by means of a ladder of ropes and lianas: for a half-hour one goes upstairs in this fashion. The slope becomes easier and we are in virgin forest. There is no path. In order to advance in the direction of the hill one must push through palms, and tree-ferns, the long spines of which make treacherous support. This is the forest zone called the "little woods" in the colonies as opposed to the "great woods" where there are great trees remarkable for their height and the size of their trunks. About ten o'clock we reached the point where the first traces of the eruption were visible. The foliage of the ferns, bananas and other plants which form the vegetation of these places was dried and reddened as if it had been burned; on the leaves and on the soil also there was a thin layer of dried mud, the remains of volcanic ejections. Here the barometer registered a height of 846 meters. From there on the volcanic mud became more and more abundant. It covers the leaves in a dry adherent mass, and on the ground it is viscous and sticky and appears like a gray clay, in some places more than a foot thick: little scintillating points may be distinguished on the surface which the lens, and later a chemical analysis, showed to be globules of iron sulphide. As we had noticed that the leaves, branches and trunks of trees were plastered with mud only on the side toward the volcano, we thought at first that the weight of the mud was sufficient to explain the inclination of all these objects; they seemed to be depressed violently, but the quantity of mud on the leaves was only a few millimeters thick and not sufficient to break the branches; we soon saw that something more than the weight of mud must be called in to account for the disorder, and a sort of chaos through which it soon became necessary to thread our way. Here were great trees broken, overturned,

twisted, not only in one direction but in all directions, and often in a direction the reverse of that affected by the weight of the mud. This brought to us the conviction that something like an explosion had taken place. The air, displaced first by hot vapors blown out of the volcano, and rushing into the vacuous places so formed, became involved in a whirl or local tornado: we say local for the signs of disturbance were only in the vicinity of the volcanic opening. The people who fled with torches from the houses lower down the slope did not have their flambeaux blown out by the wind.

Climbing higher, the mud layer became thicker making the walking difficult and woe betide those with light or ill-made shoes! At the same time the crest of the spur we were following became narrower; a moment arrived when we had on the east, on the right-hand side, the ravine of the Rivière Claire. It was this last we were following, guided by the vapors that were rising from this gorge. Beside it we walked on a high crest rising above the bottom of the valley 50 to 60 meters; at our feet the valley of the Rivière Claire was plainly visible. From this point we obtained a full view of the effects of the eruption of the 5th of August, in all its extent and horror. The verdure is absolutely gone from the place which was formerly the scene of densest foliage. Trees, leaves, flowers, all are buried as though under a gray shroud. It is the sadness of winter with the trees denuded and smutted with a black snow. Though we found no dead birds, we also heard none of them singing. The mountain whistler, whose sweet pipe is associated with the melancholy grandeur of our "grands bois," the whistler of our mountains has fled from these his former haunts; we did not even meet the deadly trigonocephalus whose home is here. A dread silence, a sky obscure by vapor, an atmosphere charged with a strong odor of sulphuretted hydrogen, complete this scene worthy of Tartarus. The slope of the bed of the ravine in the midst of all this desolation, is very steep; it extends from the east toward the west from the summit peak of Mount Pelée called "Morne LaCroix," but the bottom is not continuous; it is interrupted by several cliffs; here and there, in the midst of the general grayness rifts may be seen where the soil is rent

bare; these are crevasses made perhaps by the steam of the mountain or by earthquakes about the rent. Ancient pumices may be seen of various colors, reddish or grayish, and among these are some rare masses of gray dioritic rocks, or of porphyries that the ancient fires have hurled out of the entrails of the earth along with the pumice.

In the upper part of the valley there are rising dense sheaves of whitish smoke which mark two volcanic vents from which came the mud that covers the valley and its environment. At eleven o'clock we arrived at the level of these two craters, from which we were separated only by the valley itself. A barometer reading here gave an elevation of 966 meters above sea-level. The temperature of the air was 23°.5 at twenty-five minutes after eleven o'clock; after removing the mud, the temperature given by a thermometer buried in the soil was 21°.5; this was $\frac{3}{10}$ more than the heat found at the lower station, where the persisting vegetation protected the soil from the direct action of the sun's rays.

But this was not the upper limit of the action of the volcano. It was easy to see that mud had been thrown several hundred meters above the orifices, for the line of green verdure did not begin to appear except at the very summit of the mountain. We wished to reach the summit in order to see better the actual extent of the lands covered by erupted material, but our guides assured us that the ascent here was not possible, that we should be cut off by cliffs and that there was no path. Looking over the scene of desolation, we estimated that the action of the volcanic eruption took place within a perimeter of something more than eight or nine hundred meters.

It was necessary to go down to the bottom of the valley in order to explore and examine the orifices themselves; to do this we had to slide down, with the aid of roots and lianas, an abrupt cliff 15 or 20 meters high; the younger and more agile members of the party decided to do this under the leadership of Mr. Peyraud. As they approached the fuming vents ahead of them, they found the mud deeper; the valley was divided in two branches by a spur from the summit of the mountain. In the right hand branch are the two craters; they lie in a N-S line, separated by a space of 25 to 30 meters, in the midst of which

the waters which descend from the mountain have worn a channel 12 to 15 meters deep. At this time the vents were almost free from vapor — something hitherto unknown since the day of the eruption. Therefore it was possible to examine them thoroughly. The left hand vent opens in the right slope of the spur which divides the upper part of the valley; it is of irregular, circular form and three or four meters in diameter. From this opening the thick vapors are discharged with the greatest force; these appear brilliantly white in the sunlight, spreading to leeward in a billowy plume, but they are denser and blacker in the immediate vicinity of the orifice; the emission of vapor is not preceded by any subterranean noises. The detonating sounds heard take place at the instant the vapor escapes from the hole, and this leads us to the belief that this noise is the result of the expansion of steam in air, a phenomenon entirely comparable to the detonation of a cannon.

This opening is reached by a sort of open gallery about a meter and a half wide excavated in a reddish pumiceous rock covered with dark gray mud, which was unstable and so hot that it was impossible to hold it in the hands more than a few seconds, especially that on the immediate rim of the crater. Here the attempt was made to sound the depths of the cavern by means of a zinc pail attached to a cord. But when the cord was withdrawn the pail had disappeared without evidence as to whether the loss was due to insecure knots or the melting of solder. The cord was impregnated with a strong smell of sulphuretted hydrogen. Stones dropped into the hole were heard to fall quickly with a noise as of striking a liquid. An alcohol thermometer buried in the soil rose almost to its highest limit. The barometer gave an elevation of 883 meters, indicating that these rents were 83 meters below the summit of the spur, where the rest of us had remained.

This crater had already been visited by Mr. de Maynard but that was in the first days of its formation when steam action was so violent that details could not be seen.

Across the gulch, but separated as we have said by twenty-five or thirty meters, is the other higher orifice, and this is also the greatest vent,— it is harder to reach than the first, lying at

the bottom of a great four-sided funnel behind which is a very high cliff; this funnel opens against the wall of the cliff like a great chimney. One of the guides at that point venturing a little too near slipped on the steep slope leading to the orifice and was almost thrown in, but happily he checked himself just in time and we were saved from a horrible tragedy.

It was noon, and the openings, which up to that time had been giving off very little vapor — so that no steam could be seen from St. Pierre — began to puff and give off an odor of sulphuretted hydrogen more strongly than heretofore, and at the same time detonations could be heard. We thought of returning, but we wished to visit a third crater seen fuming some hundreds of meters lower down the same ravine, which was said to be the seat of the ancient Soufrière.

Two routes appeared practicable: the one following down the steep crest that we had come up by, in order to find, a little lower down, a less steep slope; the other going directly from the upper orifices to the one below following the same ravine longitudinally; the first of these routes was, according to the guides, the only practicable one; the other passing escarpments and cliffs led to an inaccessible point above the vent. Mr. LePrieur and I followed the guides, Mr. Peyraud and some others who were with us wished to try the more difficult route, but after much trouble, they were obliged to retrace their steps and rejoin us. They had been cut off by those precipices which on the mountain are invisible a very short distance away, but which prove when one reaches them that the straight line is not always the shortest road between two points.

After going down a half hour we arrived at the level of the third crater, but it then became necessary to drop down into the ravine for a depth of fifty feet by sliding on a slope inclined about thirty degrees. Finally we reached the bottom and found the bed of the ravine four or five meters wide, in the middle of which a swift brook runs through a bed of grayish mud. This mud has a thickness of half a meter. On the two banks rise wall cliffs eight to ten meters high. The bottom of this gorge is thus in a fashion shut in. To the east, above, in the direction of the higher vents that we had just left, the ravine is

shut off by a rock wall at the summit of which gushes out the steam of the third crater; along with the steam, a cascade of water escapes, which falls into the ravine and forms the brook mentioned. Unfortunately it was not possible to climb to the edge of this hole and get a good view of its dimensions. The cliff which rises above it at the back is hollowed out in a sort of cavern, and before it the crater forms a *v* shaped breach whence comes the water of the cascade; it is probable that the arrangement of these places changes from time to time under the different forces at work, for Mr. Peyraud who had been here in 1838, found the place unrecognizable in 1851. Besides the crater of to-day which was quite new to him, there was lacking a cold spring which our companion had promised us and which for several hours we had counted on for quenching our thirst. We found only springs of hot water, the coolest of them at 37°.

On the heights above the ravine, the Abbé Lespinasse, during the first days of the eruption, had planted a cross, in order to reassure the frightened populace. This is the only barrier that man dares oppose to threatening nature at such a time. The presence of hot water here appeared to us an important basis of more extensive study. On our right looking to the east, about a meter and a half from the bottom of the ravine and three meters from the rock wall which cuts it off, there is a hot spring having a temperature of 70°; its taste and its odor indicate the presence of sulphuretted hydrogen. The principal jet is about an inch in diameter and all about it are tiny rills at the same temperature: two meters above this first spring and a little further along there is a second spring of the same quality with a temperature of 46°, which falls, by several little cascades, on the rock, from which it rebounds below. The action of the air liberates a great part of the sulphur contained and this is deposited in a light powder on the lower rock, which is coated yellowish white, but in falling lower down on another ferruginous rock it is again decomposed and the sulphur this time combines with the iron to form a black sulphide of iron.

On the same side going higher another spring is found with a temperature of only 22°; this has a still more sulphurous taste. On the opposite bank two meters from the bottom and one

meter from the end cliff there is another sulphurous spring with a temperature of 90°. The muddy water coming down the brook has very variable temperature; during our exploration, Aug. 29, it was 37°, but on the 30th it was 65° (for the study of the springs about this third crater was found so interesting that Messrs. LePrieur and Peyraud returned twice to take the temperature and to get some bottles of water for analysis). It is to these gentlemen that we are indebted for detailed information concerning the springs; they determined that the temperature of the different springs coming out of the rock was always the same, while that of the main brook varied; this difference according to them is due to the fact that the materials thrown out of the crater mix with the water of the brook, the source of which is rainfall. This is properly the head-waters of the Rivière Claire. According as the ejectamenta are more or less abundant the water is more or less hot. This we had opportunity to prove Aug. 29th, for while we were in the ravine making observations, suddenly several detonations were heard and at the same time blacker and more abundant fumes came from the crater; the water of the brook changed quickly in temperature rising from 27° to 47°. There were twenty of us crowded together in the ravine. Nearly every one was afraid and each sought safety on the adjacent cliff a few meters high. But as this could be reached only by one very narrow path, in single file, the crowding added to our panic. To the credit of Messrs. LePrieur and Peyraud be it said they did not share our fright and remained behind facing the eruption and continuing their observations, and they did not rejoin us until a long time afterwards. At the moment of the noise and the ejection of vapor a cloud of grayish mud was thrown into the air which fell in a very fine powder on our hats and clothing. The brook increased in volume to a blackish gray boiling mass. It did not appear to ever reach a depth of more than one meter, for the mud-stains on the wall were not visible at any point above this height. After three successive explosions the crater became quiet and the vapor became whiter. It was at this time again determined that the noise took place entirely at the orifice of the vent by the expansion of steam in air, and was in no sense

subterranean, for the puff of vapor and the noise were exactly simultaneous. We saw no ejections of fire, stones, or even sand; the only accident that was somewhat remarkable was the detachment of a block of ferruginous rock from the right side of the ravine, which rolled into the depths and broke into pieces. This rock measured twelve to fifteen cubic meters. On the sixth of September, Messrs. LePrieur and Peyraud on their second return hither determined that in spite of the thick masses of vapor thrown out since the 29th of August, and in spite of rain which had fallen twice on the mountain, the level of the brook had not risen. They said that our foot-prints of the last excursion were still visible in the mud of the bottom of the ravine, some of them containing a little water, evidently from rain-fall: in the interval between the two visits there was no change, and the different springs showed the same temperature; in the spring at 70° one could boil eggs, and some of the native crawfish were found cooked.

A copper bucket was thrown into the crater securely attached to a cord; three times the vessel was thrown against the rock wall and was recovered dented, but it was not possible to obtain the slightest particle of liquid; the material of the interior was found to be reddish pumice which accounted for a reddish color that had been at one time observed in the vapor coming from this orifice. While we were there, however, this steam and that from the upper crater always appeared to us white or blackish, the last condition being due to particles of sulphurous mud.

In order to complete the exploration of the scene of eruption it remained to examine the valley where the first openings were made. For the openings that we have just described are not those which opened first. Those which are in action today opened on Saturday, the 9th of August, after a series of detonations more violent than those of the 5th. The first openings are situated in a lateral valley which joins the one where the active craters are, but much lower down. They are today entirely quiescent. From the calm which reigns in their vicinity one would never suppose that a month ago they had served to give vent to the first manifestations of a volcano. These openings are ten in number, along a single line, and trend in the

same direction as the upper vents; behind them is a high cliff which forms the right side of the ravine they occupy. The first is at the same time the lowest and smallest ; its diameter is 0.60 meter to 0.70, and its depth about 0.30 m. The bottom is covered with a reddish ferruginous sand and the rocks thereabouts are brownish and tumbled in disorder, doubtless the product of the eruption. The ravine has been deeply excavated by water which has removed the greater part of the soil and left only denuded rocks. The different openings are on a rather steep slope. The tenth which is the highest of all is also the widest and deepest ; it is four meters long and a meter and a half wide. Above there is a tree supported by its denuded roots ; this vent is quite deep and appears to contain water still, but a line forty feet long failed to reach the bottom ; the third opening, counting from below, is also of elongate shape ; it is not remarkable except that it is half covered by a boulder which has not been displaced. There are also some plants which have not been totally destroyed and their roots hang denuded in the opening. The bottom of this cavity is, like that of the other, covered by sediment colored with iron oxides. An elevation taken at half past three in the afternoon in the middle of these small openings gave 816 meters above the sea. The thermometer gave 20.5° in the air and 23.5° in the soil ; much rain fell on that day.

In returning to the habitation Ruffin and passing the Morne Plumet, — the most elevated point of this part of the mountain and hence named Gros Morne, — one does not encounter any trees, the only vegetation being shrubs, grasses and sedges ; at this height (812 meters above the sea) there is a fine view ; directly opposite is the ravine of the Claire within which are the three active openings, to the left extends all the district of Prêcheur with its picturesque farm houses situated each on its little hill, and to the right in the distance may be seen the wide landscape of St. Pierre, the city itself with its reddish roofs, and the vessels anchored in the roadstead.

The general direction of trend of the ravine where the active steaming vents are situated is ENE.[1] From the summit of the

[1] The French notation used is N. E. 1/4 SE.— W. 1/ 4 W. (ne 1/4s, e-o 1/4 o).

Morne Plumet the orifice nearest to St. Pierre (that from which the thickest fumes come) is to the east 30° north; the second is 32° north and the third which opens in the ravine is to the east 36° north. St. Pierre lies to the south 10° east [1] at a distance of about 10 kilometers as a bird flies; the town of Prêcheur is about 7 kilometers directly west. The Ruffin house, which is the nearest dwelling, is about 3 kilometers from the upper opening, and 2 kilometers from that situated above La Soufrière; the sugar factory Canonville is 5 kilometers away. From the Grande Rue du Mouillage the upper opening is north 4° east; [2] it is this which is best seen from below and from this escaped the densest vapors; these entirely mask the second opening which in this direction is behind the first; as to the vapors thrown out by the opening situated in the ancient Soufrière, they cannot be seen from St. Pierre; the high crest which separates Rivière Blanche from Rivière Claire hides this opening entirely.

The 29th of August we returned at two o'clock to the Ruffin House. Our excursion had occupied about seven hours; at the cost of some fatigue we bore with us the memory of one of the most imposing spectacles man had ever seen. But our task was not finished. We had to assure ourselves that there were no other points in the mountain where changes had taken place in consequence of the eruption of the fifth of August. Of course it was important to determine what had happened to the hot waters which exist in the part of Mt. Pelée called Montagne d'Irlande where Mr. A. Desnoux de Messirny has built a bath establishment. Sept. 2, Messrs. Le Prieur and Peyraud betook themselves to that locality and found the water of the spring itself at 35°.8, and at the first faucet of the first bath of the establishment (which is ten minutes walk distant) we found the temperature to be 33°. The weather was clear; — after heavy rains have fallen on the pipes, the loss of heat between the spring and the baths is still greater. Dr. Dutroileau who was at the establishment on account of his health on the night of the fifth of August assured us that no change happened to the water

[1] "Du compas" — presumably *magnetic*.
[2] "N 1/4 4 E."

either in temperature, volume or limpidity. The air here as in all the Prêcheur district is strongly impregnated with the odor of sulphuretted hydrogen and all silver pieces turned brown as well as those paintings which contained compounds of lead. In the night of 5th to 6th of August and the 9th of the same month strong but short shocks of earthquake were felt ; since that time the earth has remained at rest, but from time to time strong detonations may be heard, similar to cannon shots in the distance. At the same time it is stated that a movement is felt such as might be produced by a powerful blow struck beneath the soil. This sensation was also perceived at the Ruffin House but at my residence Fond Canonville, which is not on the massive rock of the hills but on the seacoast, I perceived nothing of the sort.

All along the road leading to the baths and at the spring Messrs. Le Prieur and Peyraud perceived no landslips, even though the walls of the ravine by this road are formed of tufa 20 to 25 meters in height, frequently deeply trenched. This soil is composed of pumice in masses or fragments on which the water has deposited in certain places incrustations. Above the bathing establishment toward the Carbonal House many rocks are found high up the slope which are friable and fine grained, horizontally bedded, and resting on the fragmentary pumice ; these rocks are variously colored and serve as support to the pumice ; this suggests that often eruptions had taken place, throwing out pumiceous rocks and that in the intervals the flowing water in its turn had deposited the particles held in suspension during the calm periods. Along the lower part of the road all these beds are very well shown, especially in those portions artificially trenched ; there are there several good sized heaps of ancient volcanic cinders of a faint violet tint and rather more sandy in quality than the muds thrown out today ; there are no metallic particles ; some are reddish like the sands found near the little extinct vents, or on the steep slope back of the vent called La Soufrière.

There remained another important point to determine : namely, what had happened to the actual summit of the Montagne Pelée, where there is a lake supposed to be the seat of an

ancient crater. Seen from St. Pierre the mountain did not appear to have changed at all in height, but had nothing happened to the waters of the lake? No one knew, for no one had been there since the eruption of August 5th, and on this account Messrs. Le Prieur and Peyraud resolved to explore the summit on 4th Sept. The trail to the summit of Mt. Pelée is more travelled than that which leads to the craters. The inhabitants of St. Pierre sometimes make picnic excursions to the summit. Leaving the Eynard House near the base of the mountain, the spur is followed which leads beside and overhangs the ravine of the Rivière Sêche. For three quarters of an hour one passes cultivated lands, the earth there being loose and formed of fragmentary pumice covered by a thin bed of vegetable mold which is very permeable; vegetables are raised on these slopes. Then the traveller comes to the great woods, fig trees covered by vegetable parasites, and long lianas which climb to the very summits of these forest giants and then swing back to earth where they throw out roots and form a dense mass of vegetation entirely distinctive of the tropics. On leaving these woods at the end of an hour, the trees are seen to grow smaller and are gradually replaced by low shrubby and herbaceous vegetation; but none the less the botanist finds here too a constant source of delight. I saw, wrote Mr. Le Prieur, superb flowers worthy of hot-houses, especially two superb cromelias, the one with a long spike of flowers, the other with yellow and red flowers; there are the Brazilian huckleberries, with violet-red flowers; three beautiful species of lobelia, with great flowers which recall some of the fields of certain portions of France. This last plant is found about the lake, and on the humid slopes leading to Morne LaCroix, the culminating point of the mountain — so named because a cross has been placed there. In general, of all the floras of the Antilles, that of Martinique is least known because of the trigonocephalus, whose terrible reputation frightens away the hardiest botanist. Our explorers started at seven o'clock and reached the lake at half past ten. According to the guides who are accustomed to the place no change has taken place in the lake. It is some three hundred paces in circumference; the thermometer gave a temperature in air of 19° and in

the water 20°.5. Nevertheless, the temperature seemed much colder on account of a north wind blowing strongly at the time, and the dense fog over the mountain. This prevented them from viewing the magnificent spectacle ordinarily seen when the weather was fair — a view inclusive from the Grenadines to Antigua. The water of the lake was as abundant and as clear as usual. A maceration within it of certain vegetable matter gives it a grassy taste. Before arriving at the lake it was necessary to cross a crevasse 40 m. wide, which crosses the whole width of the spur that they followed, and is well known to those who have taken this excursion. This crevasse has not been changed at all nor widened. Neither on the road nor from any point of view was any trace of disturbance seen.

The bottom of the lake is carpeted with a layer of thin mud and this rests upon a heap of fragments of pumice of yellowish gray color partly decomposed and recemented by a little ferruginous clay. On the southwest border of the lake a small beach has formed, composed of very fine grains from the debris of these pumiceous rocks which the movement of the waves, raised by the north wind, bring there continually, for there is not on that side any elevation to protect the rocks from the action of the wind. At the summit of Morne LaCroix the barometer gave an elevation of 1277 meters above the level of the sea. This is the highest point of the island. The thermometer in air gave 18°.5 and in earth 19°.2. From this point steam could be seen toward the west, coming out of the upper craters 400 meters lower down. A little more to the left not quite so far down there was seen from time to time a water surface showing bluish reflection, filling the basin called formerly by the guides the "dry pond" (étang sec), because ordinarily this basin is empty.

Even on the plants of the summit of Morne La Croix, traces of volcanic cinders were found which had been carried to this point. Messrs. Le Prieur and Peyraud, not being willing to leave the mountain without a visit to the dry pond — which is commonly believed to be another more ancient crater of the volcano — visited it during their descent by means of a trail rarely used, very difficult and seldom visited before they went

there. They found this supposed "dry" pond filled by a considerable mass of water and according to their estimate five times greater than the upper lake: the guides attributed the presence of this water to the abundant rains which had truly been extraordinary during the "hivernage" of 1851; they asserted that during the previous lenten season this pond had been dry.[1]

The barometer here gave an altitude of 921 meters above the level of the sea. Thus this dry pond is at almost the same elevation as the upper vents of the volcano which are in a ravine beyond. Nothing else was found changed in these localities according to the guides, and nothing in the way of fissures nor disturbances. After this last expedition our official work was finished; we had learned that the action of the volcano did not extend beyond the limits we had explored, and that it was confined to the ravine where the Rivière Claire takes its rise and that immediate vicinity. It was useless to examine the northern slope of mountain toward Macouba, for the inhabitants of that quarter observed nothing extraordinary except an odor of sulphuretted hydrogen, which, it is said, was perceived even as far as St. Marie. At Macouba the leaves of the trees were coated with only the barest trace of those cinders which caused such a fright in St. Pierre.

[1] Some naturalists think that the heat of certain volcanoes comes from no great depth and the water which they throw out is merely rain water which penetrates by means of the fissures in the earth and accumulates in subterranean cavities; several of the observations made during our eruption of the fifth of August lend support to this opinion: (1) the years 1850–1851 had been very rainy, so much so that the dry pond of the mountain has been found full of water and this has become for us a sort of pluviometer; (2) the shocks of earthquake and sensation of bumping under the soil were felt only on the slopes of the mountain, in those little estates situated probably above the level of the seat of volcanic activity — in those which are below this level on the flat land or on the seashore (as at my house in Fond Canonville) although they are still sufficiently near the volcano, nothing of the sort was felt. Moreover at Fond Canonville the springs which escape from the foot of the surrounding hills, like the Fontaine Chaude, have not been in any way changed. It seems to me there is great probability that the volcanic furnace is in the body of the mountain and not at its roots.

Conclusions.

Doubtless no dissertation will be expected from us on the cause and nature of the Mt. Pelée volcano. This study would require a professional knowledge other than we possess; we have merely tried to fulfill the request of the government and report upon the extent of the accidents occasioned by the eruption of the 5th of August and certain exact details. We will vouch for nothing beyond the facts which we ourselves have determined. If these facts, compared with those possessed by science already à propos of the other volcanoes of the earth (more than two hundred in number) can throw some light on the nature of this great phenomenon we shall be well satisfied. But it is not our task to enter upon such matters. The following we can vouch for: —

The eruption of the fifth of August was entirely a local event bounded by the ravine of the Rivière Claire, devastating an area 800 to 900 meters broad at the outside.

The effects of the eruption were at first a continuous buzzing sound, then a series of intermittent detonations, and simultaneously there was thrown out a jet of white or black vapors which made a deposit wherever they spread in the shape of a grayish mud or cinder; and these vapors produce in their vicinity a strong odor of sulphuretted hydrogen.

It is not possible to assert whether this material is always thrown out in the form of cinders or powder, or not sometimes in the form of a rain of mud. It is more probably in a powdery condition and when it falls on the trees it is moistened by steam, or when it falls on the ground it becomes mixed with rain water and forms a sort of clay.

The eruption of the fifth of August was not accompanied by any noticeable earthquake in Martinique, even in the Prêcheur district. Since that time no shocks have been felt. In this respect the opening of these vents seems to be for our island a happy event, a kind of safety valve giving vent to subterranean gases and vapors and so protecting us from those earth commotions which formerly produced such desolation here. "It happens," says Buffon, "that in the lands subject to earthquake,

when a new volcano breaks out earthquakes cease and are only felt during the violent eruptions of the volcano; this has been observed on the island of St. Christopher; and the great encyclopædia begins its article on "volcanoes" as follows: "Volcanoes are a beneficent device of nature, etc. etc."

The buzzing sounds of detonations are not produced by subterranean ebullition, but they take place simultaneously with the ejection of vapor and are produced at the orifice of the vent.

The cinders or muds are the only materials thrown out by the volcano. We have found neither lavas, nor even stones of the smallest possible dimensions which could be identified as eruption products.

The geological structure of Mt. Pelée, as far as our incomplete observations go, shows no lava flows: "for we must not include under the name of lavas," says a geologist, "all the materials ejected from the throat of a volcano such as cinders, pumice stones, gravels, sand; but only those which, reduced by the action of heat to a liquid condition, form on cooling solid masses the hardness of which is greater than marble." These lavas exist principally in the vicinity of volcanoes which eject fire. Now we find about our volcano only pumice, generally fragmentary, and some deposits of cindery substance, in the middle of which appear diorite fragments, torn out of the interior of the earth in preceding eruptions.

This geological structure of Mt. Pelée leads to the belief that the earlier eruptions (which show at least two craters, the dry pond and the lake above) have been of the same nature as that of the fifth of August. Everything goes to show that this volcano should be ranked with the cinder, or mud volcanoes, and not with fire volcanoes (volcans de feu).

Compared with the common notion of the Soufrière of Guadeloupe, what we have learned concerning the new vents of Mt. Pelée is closely similar. It is probable that the conditions are about the same in the case of the Soufrières of St. Lucia, Dominica and Montserrat.

As to Guadeloupe, there have been eruptions several times, notably in February 1837, and December 1846.

These eruptions have always opened new fumaroles and ejected cinders and thick mud.

Mt. Pelée when closely examined shows no fissures, landslips, nor displacement of waters, and hence the action of the eruption of the fifth of August was very local.

The city of St. Pierre situated more than ten kilometers away, and the town of Prêcheur distant seven kilometers, appear to be out of danger from eruptions even considerably greater than the one which has taken place. Nothing in the land where they are situated indicates great catastrophes. Even to reach the Ruffin House or the Eynard House, which are nearest to the vents, a disturbance would be necessary very different from the present one. The matter thrown out even in the immediate vicinity of the vents did not reach a depth of more than a meter. This material finds a natural path of flow in consequence of the steep slope and the gorge of the Rivière Blanche whose waters naturally carry it off to the sea. Further the planters who fled at first have since returned to their dwellings, and their work, and have no further fear of the noises heard from time to time nor of the odor of sulphuretted hydrogen that is continually perceptible.

This odor impregnates the atmosphere all about Mt. Pelée and extends even beyond. It augments or diminishes in certain places according to the direction of the wind; it is sometimes comparable to the odor of burnt gunpowder, at other times to that of stirred up swamp mud; up to this time this odor appears to be merely disagreeable and has had no unsanitary effect either upon men or animals. However, for some time I have been struck with the large number of persons of the Prêcheur district, especially on the habitation Beligny and in my own plantation, who have consulted me about skin troubles and insomnia which they attribute to the sulphurous emanations. I have seen cows drinking the muddy water of the Rivière Blanche and the proprietor assures me that they suffered no ill effects. I have not observed any flight of the birds away from the district though one would suppose their respiratory systems must be very sensitive. Silver pieces in all the estates of the Prêcheur quarter turn brown, and so do all paintings which contain compounds of copper or lead. It is worthy of note that at Guadeloupe the exhalations of sulphuretted hydrogen are not perceived in the

vicinity of the Soufrière — hence we may hope that here also they may cease in due time. No great deposits of pure sulphur have been found either here or in Guadeloupe. Everywhere the sulphur appears to be in a state of combination.

Moreover it should be observed that the presence of sulphuretted hydrogen in the atmosphere in all those localities where there are thermal sulphur waters is not regarded as unhealthy; the waters of Vernet and of Cauterets give out these exhalations and they are believed salutary for people with pulmonary trouble, therefore we may hope that the Prêcheur district, already renowned for its therapeutic qualities in the treatment of these diseases, may acquire a new title to fame in the eyes of such invalids.

But the most remarkable result of our excursions and the most interesting is the information about the place formerly called La Soufrière. There in a very small area four springs of different temperature occur close together, of which three are sulphurous at temperatures of 90°, 70°, and 46°. The other is cold with a temperature of 22.5° and while not being very good to drink is not the less potable. The hot springs contain free sulphuric acid (acide sulphydrique) which volatilizes in consequence of the heat and leaves a residue on evaporation weighing two drachms for each meter of water; this residue of soluble salts contains sulphuric acid and hydochloric acid combined with soda, potash, magnesia, lime and iron as well as a small quantity of silica.

It is to be hoped that at some time when calm shall have been re-established at the seat of eruption, and in the minds of the inhabitants, that some bold speculator will turn to our advantage that which has given us such a fright and will build an establishment of thermal waters in the midst of these places now so desolate. These waters could be conducted to a reservoir so disposed, that their high temperature might be reduced without the loss of their beneficial properties.

Summing up the volcano La Montagne Pelée, it appears to be merely one more interesting curiosity added to the natural history of Martinique — a curiosity that foreigners will wish to visit and which with fitting industry on the part of the natives may

be made a source of health and wealth — in calm weather the ships coming from France will see from a distance the long billow of white vapor rising straight toward the heavens, and will find this a picturesque addition to the landscape — the last touch needed to complete the majesty of our ancient Montagne Pelée.

NOTES AND LITERATURE.

ZOÖLOGY.

Birds in their Relation to Man. — Mrs. Florence Merriam Bailey in her "Birds of Village and Field" included much matter relative to the food of birds, based on the reports of the Dept. of Agriculture; nothing has since been done to put before the public a systematic compilation of the results of the work which this Department has done. Prof. Weed attempted to give a senior class in the New Hampshire Agricultural college a course in economic ornithology. His book "Birds in their Relation to Man"[1] has developed from the series of lectures which he wrote for this object. The work should be an effective agent in informing the general public of the part birds play in the garden, field and forest. Man in his relations to birds comes in for treatment, and it is only thanks to a few honored names such as Wilson, Forbes, Beal and Palmer, that the prevailing record of short-sighted selfishness and ingratitude is lightened.

The book begins with a chapter on methods of studying the food of birds, the only really satisfactory ones being that of the Dept. of Agriculture, the examination of stomachs; and that of Prof. Herrick, the study of nestlings from a tent; the development of the study of economic ornithology is then briefly treated. The next three chapters treat in general the vegetable and animal food of birds; then follow chapters on the amount of food of birds; birds as regulators of outbreaks, and the relations of birds to predaceous and parasitic insects. Nearly half the book is devoted to the food of the separate families of birds as illustrated by typical examples. The bulletins of the Dept. of Agriculture naturally form the basis of this part of the work, with the result that while the passerine orders are well-covered, the food of the water-birds, among which little systematic work has yet been done, is very inadequately treated. Interesting chapters follow on the "conservation" of birds including an account of legislation lately enacted, and helpful suggestions for resisting the attacks

[1] Weed, C. M. and Dearborn, N. *Birds in their Relation to Man.* London. Lippincott. 8vo, pp. 380. With numerous full-page illustrations, cuts, diagrams, etc.

of injurious birds without indiscriminate onslaughts on the whole species. There are four valuable appendices, the first three dealing with protective legislation, the fourth a bibliography of economic ornithology.

There is naturally considerable unevenness of treatment in the account of the food of birds due to the gaps in our present knowledge of the subject, but the matter at Prof. Weed's and Mr. Dearborn's command, is presented clearly and in a scientific spirit. The doubtful birds, the crow, the crow blackbird, the bobolink, etc., are treated in an unprejudiced spirit: — they receive justice tempered with mercy. The book is intended not so much as a storehouse of facts, as a powerful argument, which cannot fail to have a very beneficial influence with the reading public.

The illustrations will give the book a little more favor with the people, and thus are a help. The cuts on pages 137 and on 139, however, are of doubtful value and the full page illustration on page 59 called American Long-eared Owl looks very much like a Short-eared Owl.

R. H.

BOTANY.

The Morphology of Angiosperms.[1]— For several years past there has issued from the Botanical Department of the University of Chicago a series of studies upon the embryo-sac and related topics, some of which have been important contributions to the subject. These papers form the basis of the present volume, which has been prepared by the head of the department, with the assistance of Dr. C. J. Chamberlain. While the book contains little material that has not appeared before, nevertheless it can claim to be based, to a considerable extent, upon work done under the supervision of the authors. Evidently an enormous amount of literature has been gone over, and on the whole, the summarizing of the results has been well done, and the book will be very useful to the student who wishes to know the present status of the subject. One would feel more confidence in some of the conclusions reached by the authors, if these were based to a greater degree upon first-hand observations; but it is quite pos-

[1] Coulter, J. M. and Chamberlain, C. J. *Morphology of Angiosperms.* N. Y. Appleton & Co. 1903. pp. vii + 348.

sible that there is less personal bias than would be the case in a work based mainly upon the personal investigations of the writers.

The title of the book is, perhaps, somewhat misleading, as it deals only briefly with general morphology; but we think the authors have done well to restrict it mainly to the sporangium, gametophyte and embryo, since a general morphology of the vast group of Angiosperms could hardly be compressed within the limits of a single volume.

The book comprises seventeen chapters, of which the first nine will be found of the greatest value to the student for reference. In these the general morphology of the flower, the microsporangium, macrosporangium, male and female gametophyte and embryo are treated in detail, and on the whole extremely well.

The chapter on the flower is in our opinion one of the very best in the book. The author (we assume the senior author) shows here a sureness of treatment which comes only from an intimate first-hand knowledge of his subject, this being by no means so evident in some of the succeeding chapters, especially the one on the microsporangium, which immediately follows this chapter on the flower.

The chapter on the microsporangium opens with the remarkable statement that the *microsporangium* is derived from the periblem. To the reviewer is credited the statement that in Naias the sporangium arises from the plerome — a statement which it may be remarked, he did *not* make. There seems to be a curious confusion in the authors' minds between the terms "sporangium" and "sporogenous tissue."

We cannot accept the view here set forth, that the microsporangium in the Angiosperms is an endogenous structure. The author seems to have in mind the obsolete theory of the imbedding of an originally superficial structure, a view which is directly contrary to the conclusions of the most recent studies on the development of the sporangium. It is now pretty generally admitted that the eusporangiate type, such as that of the angiosperms is the more primitive form of sporangium, and the authors themselves assume the origin of the angiosperms from some form of eusporangiate pteridophyte. The close resemblances in the development of the sporangia between the latter and the angiosperms are familiar to every one who has made a direct study of the subject. We do not believe that the assumed difference in the origin of the archesporium is so fundamental as the authors claim.

It is strange that the most important work of recent years, bearing on the comparative development of the sporangium should be quite ignored. It seems hardly possible that the authors are not

acquainted with Bower's magnificent series of monographs on this subject, but we can find no reference to them in the book.

The idea of an imbedded sporangium seems to have been taken from the older German texts; but a careful study of the context, in either Goebel or Strasburger, will show that both of these authors consider the whole of the superficial tissue of the loculus, as forming the wall of the sporangium, and the whole pollen-sac as the direct homologue of the microsporangium of the pteridophytes.

It seems to be also assumed, although we can see no warrant for this, that the nucellus represents something more than a macrosporangium.

As might be expected, the development of the embryo-sac is given very complete treatment, the chapter dealing with this important topic comprising fifty pages, of which four are devoted to the bibliography. Much of the matter in this chapter is taken from the numerous papers which have been issued from the botanical laboratory of the University of Chicago, and many of the copious illustrations are drawn from the same sources. This chapter will probably be found the most useful in the book. The extensive literature of the subject has been carefully reviewed, and on the whole, little exception can be taken to the references selected to form the bibliography appended to the chapter. A great many facts are presented, and although the very number may be rather confusing to one unfamiliar with the subject, the chapter will nevertheless, give the student an excellent idea of the present status of our knowledge of the development of the embryo-sac.

The male gametophyte, naturally, has less space devoted to it, but is sufficiently complete. We should like to call the authors' attention to a mis-statement. The male prothallium of Sparganium is not referred to at all in the preliminary paper quoted, but was first described in the more complete monograph[1] published subsequently, and which seems to be unknown to the authors.

Chapters seven and nine are concerned respectively with Fertilization, The Endosperm, and The Embryo.

The chapter on Fertilization is well up to date, and gives a clear account of the latest studies upon this important topic. The chapter on the Endosperm is not so satisfactory, a number of more or less important omissions being noted. Thus no mention is made of the peculiar behavior of the lower endosperm nucleus in Naias.

[1] Campbell, D. H. Studies on the Flower and Embryo of Sparganium. *Proc. Cal. Acad. Sci.* Botany, Vol. 1, No. 9, 1899.

The treatment of the embryo is very satisfactory and leaves little to be desired. The discussion of parthenogenesis and polyembryony is especially good.

Except for the chapter on the phylogeny of the angiosperms, the latter chapters might have been entirely omitted without the value of the book being seriously impaired. The chapters on classification are entirely too brief to be of much value to the beginner, and the specialist will prefer to consult Engler & Prantl's *Natürliche Pflanzenfamilien*, from which the substance of these chapters is borrowed.

The chapter on geographical distribution is very fragmentary, and leaves something to be desired, also, in the matter of accuracy. For instance, we doubt whether the statements as to the relative numbers of Archichlamydeæ Sympetalæ and Monocotyledons will bear close examination. Thus the statement that the Archichlamydeæ and monocotyledons are relatively more numerous in the tropics than in temperate regions may be questioned. In round numbers the species of monocotyledons. Archichlamydeæ and Sympetalæ are 20,000, 60,000 and 40,000. A tabulation of the number of species in the Northeastern states is given in Britton & Brown — the numbers are respectively 1058, 1601 and 1361. It is thus seen that while the Sympetalæ are relatively slightly in excess, this is very much more marked in the monocotyledons, which our authors assert are relatively more numerous in the tropics. Two tropical floras were examined, Hawaii and the West Indies. In the former the figures are taken from Wallace's *Island Life*. The numbers are monocotyledons, 137; Archichlamydeæ, 271; Sympetalæ, 318. There is thus a marked predominance of Sympetalæ, and a deficiency of Monocotyledons and Archichlamydeæ, directly the reverse of the statement given by the authors. In the West Indies (Griesebach, *Flora of the British West Indies*) the numbers are approximately, Monocotyledons, 713; Archichlamydeæ, 1456; Sympetalae, 913. The monocotyledons in both cases are relatively less abundant than in the strictly temperate flora of the Northeast United States.

The statement that the Archichlamydeæ have developed no characteristically boreal group, while the Ericales are essentially boreal, is not in accordance with the facts. The authors themselves have called attention to the peculiarly *austral* family of Ericales, the Epacrideæ, and scattered ericaceous genera occur in the tropics, both of the old and new worlds. We should certainly consider the Salicales as quite as distinctively a boreal group as the Ericales.

The chapter on the phylogeny of the angiosperms contains much

of interest, and is clearly written. The recent speculations upon the relation of angiosperms and gymnosperms; the connection between monocotyledons and dicotyledons, are given due attention. In the discussion of the question of the possible monocotyledonous affinities of Podophyllum, it may be said that the suggestion that the two apparent cotyledons are possibly one, *morphologically*, was *not* suggested by Holm. Much stress is laid upon the somewhat dubious "Pro-angiosperms" of the lower Cretaceous. These are supposed to have arisen from some eusporangiate filicineous stock and to have given rise, independently, to the monocotyledons and dicotyledons. If we are to assume that the angiosperms are monophyletic, it is considered that the monocotyledons are probably derivations of the dicotyledons. The recent mutation theory of De Vries is also given due attention.

Prof. Jeffrey's contribution of two final chapters on the vascular system has some value in itself, but comparatively little bearing upon the morphology of angiosperms. Of twenty pages, less than six deal with angiosperms, and of thirty-three figures only five represent this group. These chapters seem to us unnecessarily loaded with technical terms, and are by no means easy reading.

D. H. C.

Notes. — No. 25 of the new series of "Contributions from the Grey Herbarium of Harvard University," issued as No. 5 of the current volume of *Proceedings of the American Academy of Arts and Sciences*, on Sept. 25, is an important paper by Greenman on Mexican and Central American Angiosperms, mostly of recent collection.

An account of an ecological study of Big Spring Prairie, Wyandot County, Ohio, by Bonser, is published as no. 7 of the *Special Papers* of the Ohio State Academy of Science.

Vol. 3, fascicle 1, of Urban's *Symbolæ Antillanæ*, dated September 16, contains the first part of a "Flora Portoricensis," by Urban.

Fascicle 126 of the *Flora Brasiliensis*, issued in December, 1902, concludes Vol. 3, part 5, of the work, dealing with orchids.

The long-delayed number needed to complete the 1901 volume of the *Bulletin de la Société Botanique de France*, dealing with the 1901 session in Corsica, contains important data on the flora of that island, including an especially full account of the fungi.

An account of the vegetation of Corsica, with photograms, by Rikli, is published in the *Viertel-Jahrsschrift der Naturforschenden Gesellschaft in Zürich*, of Apr. 11, 1903.

Vol. 2, fascicle 5, of Coste's *Flore descriptive et illustrée de la France, de la Corse et des Contrées limitrophes*, carries the work into Solanaceæ.

With volume 8, issued in April, 1903, the Rouy, Foucaud and Camus *Flore de France* is brought to a conclusion, and correction sheets for the earlier parts are added to this volume.

An account of the flora of the Sundribuns, by Crain, is published as Vol. 2, no. 4, of the *Records of the Botanical Survey* of India; and from the Government Printing Office at Calcutta is being issued a Flora of the Upper Gangetic Plain, and of the adjacent Siwalik and Sub-Himalayan Tracts, by Duthie, — the first part covering Ranunculaceæ to Cornaceæ.

The first fascicle of an illustrated quarto treatise on the botany of the middle and lower Congo, by de Wildeman, has been issued as a part of the *Annales du Musée du Congo*, of Brussels.

Volume 35 of the *Transactions and Proceedings of the New Zealand Institute*, as is usual with that publication, contains a number of important botanical articles.

Recently issued parts of Engler's *Das Pflanzeureich* are the following: — 12, Pfitzer, Orchidaceæ-Pleonandræ; 13, Ruhland, Eriocaulaceæ: 14, Grosser, Cistaceæ; 15, Mez, Theophrastaceæ.

A paper on root, stem and leaf structure of *Eschscholtzia californica*, by Denniston and Werner, is contained in Vol. 6, no. 8, of *Pharmaceutical archives*.

Under the name *Wittia Amazonica*, Schumann describes and figures in the *Monatsschrift für Kakteenkunde*, of August, a new generic type of cactus from Peru, of the aspect of Phyllocactus but with small red flowers.

The *Revista do Centro de Sciencias, Letras e Artes de Campinas*, of July 31, contains a description and figure of *Rhipsalis pilocarpa*, by Löfgren, and diagnoses and illustrations of a number of other new Brazilian plants by Edwall.

The *Monatsschrift für Kakteenkunde*, of September 15, contains descriptions of several new cacti.

Cereus gummosus, as it grows in Lower California, is figured by Schumann in the *Monatsschrift für Kakteenkunde*, for July 15.

The *Gardeners' Chronicle* of August 8 may be called an Opuntia number, with numerous illustrations of this genus as cultivated at La Mortola.

A cristate tree of *Cereus giganteus*, in situ, is figured by Mrs. Drennan, in *Floral Life* for September.

A good figure of *Yucca glauca*, as it grows in Colorado, is printed in *Floral Life* for August.

Excellent practical instructions for the collection of herbarium material of palms are given by Dammer in the *Notizblatt des K. botanischen Gartens und Museums* of Berlin, of July 10.

A paper on the phylogeny of Angiosperms, resuming publications in the *Botanical Gazette*, is reprinted by Coulter from Vol. 10 of the *Decennial Publications* of the University of Chicago, under date of April 1.

The endogenous adventive buds of several genera of phanerogams are considered by De Candolle in a separate from the *Archives des Sciences Physiques et Naturelles* of Geneva, for July.

The structure of a number of the woods of Borneo is described by Bargagli-Petrucci, and illustrated with photograms, in fascicle 6–8 of *Malpighia* for 1903.

The first part of a study of the comparative anatomy of the barks of the Salicaceæ, by Perrédès, is published as No. 39 of the papers from the Wellcome Chemical Research Laboratories, of London.

The root anatomy of Angiosperms is the subject of a paper by Kroemer, forming Heft 59 of *Bibliotheca Botanica*.

Variation in the androecium of *Stellaria media* is discussed, with curves, by Reinöhl, in the *Botanische Zeitung*, I Abteilung, of September 16.

A paper on the development of the fruits in heterocarpic Composites is published by Patané in *Malpighia*, Vol. 17, fascicle 9.

Dr. Chamberlain's paper on Mitosis in Pellia, contained in the *Botanical Gazette* of July, is concurrently issued from Vol. 10 of the *Decennial Publications* of the University of Chicago.

The application of the kinematograph to the class presentation of plant movements is continued by Miss Scott in a paper on the movements of the flowers of *Sparmannia africana* in the *Annals of Botany* of September.

The spurting of water from the leaf-tips of *Colocasia nymphæfolia* is considered by Molisch in the *Berichte der deutschen Botanischen Gesellschaft* of September 21.

The phenological relations of sun-spots form the subject of a short note, with curves, by MacDowall, in *Nature* of August 27.

An illustrated account of the lumber industry of the Northwest coast, by Lamb, is contained in *Out West* for October.

A nicely illustrated popular article on Elm and Tulip trees, by McFarland, is contained in *The Outlook* of October 3.

An economic account of Zizania, by Brown and Scofield, is published as *Bulletin No. 50* of the Bureau of Plant Industry of the United States Department of Agriculture.

The differentials of varieties of Avena, and those of Triticum, are respectively discussed by Dufour and Dassonville in the *Revue générale de Botanique* of July 12, and Scofield in *Bulletin No. 47* of the Bureau of Plant Industry of the U. S. Department of Agriculture.

An account of rattans and the rattan industry is contained in the *Agricultural Bulletin of the Straits and Federated Malay States*, for April and May last.

An illustrated paper on origin and distribution of camphor in the camphor tree, by Homi Shirasawa, is published in Vol. 5, no. 3, of the *Bulletin of the College of Agriculture* of the Tōkyō Imperial University.

In the *Pharmaceutical Review*, of September, True shows that under the name of Pink-root *Ruellia ciliosa* occurs in the trade, as well as *Spigelia marilandica*.

A well illustrated account of *Castilla elastica* and the Central American production of rubber from it, by Cook, forms *Bulletin no. 49* of the Bureau of Plant Industry of the U. S. Department of Agriculture.

The first of a series of notes on latex-yielding Apocynaceæ of the Congo, by De Wildeman, has been issued at Brussels as a publication of the Independent State of the Congo.

An account of the root-parasitism of the sandal tree, by Rama Rao, is contained in *The Indian Forester* of September.

An account of the Isoetes of southern California is compiled for the *West American Scientist* of September.

Helpful notes on the collection and cultivation of cryptogams for use in the biological laboratory are contained in current numbers of the *Journal of Applied Microscopy and Laboratory Methods*.

An annotated edition of the Codex of Clusius, the original of which appeared three centuries ago, has recently been issued by Istvánffi, of Budapest, and is illustrated by colored reproductions of the original water color sketches of fungi, by Clusius.

A key to the species of Rhizopus, with description of a new parhogenic species, *R. equinus*, is published by Costantin and Lucet in the July number of the *Bulletin trimestriel de la Société mycologique de France*.

A note on Costa Rican edible fungi is contained in No. 24 of the *Boletin el Instituto Fisico geografico de Costa Rica*.

Several edible fungi are illustrated in the *Gardener's Chronicle* of September 19.

Inoculation experiments with graminicolous species of Claviceps are described by Stäger in the *Botanische Zeitung*, Abteilung 1, of July 30.

Some decay of stored apples is shown by Eustace, in *Bulletin No. 235*, and the popular edition of the same, of the New York Agricultural Experimental Station, to be caused in part by a species of Hypochnus following Fusicladium, and in part to be of an obscure origin, without any parasitic cause so far as determined.

Oudemans and Koning have distributed two recent papers on a new Sclerotinia of tobacco, from the Amsterdam Academy.

An economic account of the wilt disease of tobacco, caused by a species of Fusarium, forms the subject of part 1 of *Bulletin No. 51*, of the Bureau of Plant Industry of the United States Department of Agriculture, by McKenney.

An important paper on the bacteria of tilled soil, by Hiltner and Störmer, forms Vol. 3, Heft. 5, of *Arbeiten aus der Biologischen Abtheilung für Land und Forstwirthschaft am K. Gesundheitsamte*, of Berlin.

Bacteria and the Nitrogen Problem is the title of an article by Moore, separately printed from the 1902 *Yearbook* of the Department of Agriculture.

An extended consideration of the significance of bacteriological methods in sanitary water analysis, by Winslow and Nibecker, is contained in the *Technological Quarterly* for September.

An account of the lichens of the northern boundary of Minnesota, by Fink, is separately printed from *Minnesota Botanical Studies*, under date of July 3.

Vol. 4 of De Toni's *Sylloge Algarum*, recently issued, continues the Florideæ.

An account of the algæ which contaminate public water supplies, by Moore, is separately printed from the *Yearbook* of the Department of Agriculture, for 1902.

A most interesting portrait gallery of distinguished botanists is contained in Professor Wittrock's "Catalogus Illustratus Iconothecæ Botanicæ Horti Bergiani Stockholmiensis," issued as Vol. 3, No. 2, of the *Acta Horti Bergiani.*

A portrait of Celakovsky forms the frontispiece to the *Sitzungsberichte der k. böhm. Gesellschaft der Wissenschaften — Mathematisch-naturwissenschaftliche Classe*, for 1902.

A short account of the San Salvador botanical garden is contained in the *Anales del Museo Nacional* of that Republic, of August 1.

A sketch of the botanical gardens at Frankfurt am Main, by Möbius, is separately printed from the 1903 *Bericht der senckenbergischen naturforschenden Gesellschaft.*

The Journals. — *The American Botanist*, for July, contains the following popular articles: — Bradshaw, "The Castor-oil Plant"; Hæselbarth, "The Walking Fern"; and Clute, "Pollination of the Sunflower."

The *Botanical Gazette*, for August, contains the following: — Lawson, "Studies in Spindle Formation"; Frye, "The Embryo-sac of *Casuarina stricta*"; Coker, "The Gametophyte and Embryo of Taxodium — concluded"; Bliss, "The Occurrence of two Venters in the Archegonium of *Polytrichum juniperinum*"; and Cook, "Polyembryony in Ginkgo."

The Botanical Gazette, of September, contains the following articles: — Ganong, "The Vegetation of the Bay of Fundy salt and diked Marshes"; Shull, "Geographic Distribution of *Isoetes saccharata*"; Parish, "A Sketch of the Flora of Southern California"; Thom, "A Gall upon a Mushroom"; and Coker, "Selected Notes, II. — Liverworts."

The Bryologist, for September, contains the following articles: — Gozzaldi, "Thomas Potts James," with portrait; Holzinger, "*Fabroleskea austini* in Europe"; Chamberlain, "Mounting Moss Specimens," and "*Buxbaumia aphylla*"; Harris, "Lichens — Nephroma-Solorina"; Hill, "Branched Paraphyses of *Bryum roseum*"; and Lindberg, "*Stereodon plicatulus*."

The *Bulletin of the Torrey Botanical Club*, for August, contains the following: — Murrill, "The Polyporaceæ of North America — V, The Genera Cyrtoporus, Piptoporus, Sentiger and Porodiscus"; "Mez, Bromeliaceæ Nicaraguenses Novæ"; Berry, "The American Species referred to Thinnfeldia"; Wiegand, "Some Notes on Juncus"; and Nash, "Revision of the Family Fouquieriaceæ."

The *Bulletin of the Torrey Botanical Club*, for September, contains the following: — Best, "Revision of the North American Species of Leskea"; Eastwood, "New Species of Western Plants"; MacDougal, "Some Correlations of Leaves"; and Cushman, "Desmids from Bronx Park, New York."

The Fern Bulletin, for July, contains the following articles: — Fitzpatrick, "The Fern Flora of Iowa"; Clute, "Fernwort Notes, III"; Eaton, "The genus Equisetum in North America, XIV, *E. hiemale*"; Gilbert, "Campbell Easter Waters" (with portrait); Gilbert, "*Asplenium muticum*"; Flett, "The Fern Flora of Washington"; Christ, "Can *Scolopendrium lindeni*, Hook. "be separated from *S. vulgare* Sm.?" and Gilbert, "Two New Varieties of the ternate Botrychium."

The Plant World, for August, contains the following articles: — Safford, "Extracts from the Note-book of a Naturalist on the Island of Guam, IX"; Straw, "Ferns of Smugglers' and Nebraska Notches"; Spaulding, "The Relations of Insects to Fungi"; Barrett, "The Birthplace of Agriculture"; Lindahl, "A fasciated Tulip"; and Waters, "Some Summer Observations."

The Plant World, of September, contains the following articles: — Baum, "The Breadfruit"; Bailey, "Lianes"; Safford, "Extracts from the Note-book of a Naturalist in Guam, X"; Goetting, "The Leucocrinum"; and Barrett, "Three Ecological Problems."

Rhodora, for August, contains the following articles: — Fernald, "American Representatives of *Luzula vernalis*"; Phelps, "An Hour in a Connecticut Swamp"; Webster, "A Beautiful Pluteolus";

Collins, "Some Notes on Mosses"; Eames, "The Dwarf Mistletoe in Ct."; and Collins, "Notes on Algæ, V."

Rhodora, for September, contains the following articles: — Eames, "The Dentarias of Connecticut"; Collins, "Isaac Holden"; Cushman, "Notes on New England Desmids, I"; Fernald, "*Arabis drummondii* and its relatives"; Collins, "Notes on Algæ, VI"; Robinson, "On the Twelfth List of New England Plants"; and a short notice of the late Charles James Sprague.

Torreya, for September, contains the following articles: — Berry, "Liriodendron Notes"; Robinson, "The Distribution of *Fucus serratus* in America"; Earle, "Key to the North American Species of Galera"; Richards, "An improvised horizontal Microscope"; Griggs, "A remarkable Physalis"; Cockerell, "Two Orchids from New Mexico"; Small, "The Habitats of *Polypodium polypodioides*"; and Barnhart, "Duplicate Binomials."

CORRESPONDENCE.

To the Editor of the American Naturalist:

Sir:— In *The American Naturalist* June, 1903, p. 385, Mr. J. H. Powers says that the metamorphosis of *Amblystoma tigrinum* is due to nutritive causes. Be pleased to rectify that the same conclusion was published by me August, 1899, in *La Naturaleza*, Ser. ii, F. iii, p. 369. The title of my notes is as follows:

"El Ajolote sufre la metamorfosis general en la clase de los batracios, par aumento de nutricion y no por cambia de medio."

Experiments and observations in the latter where Amblystoma was first observed, show that metamorphosis is very slow in artificial or natural conditions, if the animals are feeble, and very rapid in the best conditions of nutrition as in deep waters of Xochimilco, a lake that never becomes dry.

The dogmatical views on adaptation of Amblystoma are wrong and the paper of Mr. Powers has only attested my own published conclusions.

I am very respectfully yours,

A. L. HERRERA.

Mexico, Oct. 12, 1903.

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

BACON, E. M. Boston, A Guide Book. Prepared for the Convention of the National Educational Association, July 6–10, 1903, etc., etc. Boston, Ginn & Co., 1903. x + 190 pp., maps and illustrations.— BAKER, F. C. Shells of Land and Water. A Familiar Introduction to the Study of the Mollusks. Chicago, A. W. Mumford, 1903. 8vo, xvii + 175 pp., 8 colored pls. and many text figs.— BURKETT, C. W. STEVENS, F. L. and HILL, D. H. Agriculture for Beginners. Boston, Ginn & Co., 1903. 8vo, xii + 262 pp., 215 figs. — COMSTOCK, ANNA B. Ways of the Six-Footed. Boston, Ginn & Co., 1903. 8vo, xii + 152 pp., 47 figs.— DODGE, C. W. General Zoölogy. Practical, Systematic and Comparative. Being a Revision and Rearrangement of Orton's Comparative Zoölogy, New York, American Book Co., 1903. 8vo, 512 pp., 379 figs. $1.80.— GARDINER, J. S. The Fauna and Geography of the Maldive and Laccadive Islands. Being the Account of the Work Carried on and of the Collections made of an Expedition during the years 1899 and 1900. Vol. ii, Part 1, pp. 473–588, pls. 26–34.— HIGGINSON, E. Map of the Republic of Peru. London, 1903.— HUNTER, S. W. and VALENTINE, M. C. Laboratory Manual of Biology. New York, Henry Holt & Co., 1903. 8vo, xii + 215 pp.— JONES, L. H. The Jones Readers 1–5. Boston, Ginn & Co., 1903. 8vo, 1, 160 pp.; 2, 208 pp.; 3, 286 pp.; 3, 416 pp.; 5, 496 pp. Many illustrations, partly colored.— KELLOGG, V. L. First Lessons in Zoology. New York, Henry Holt & Co., 1903. 8vo, x + 363 pp., 257 figs.— MILLER, D. R. The Criminal Classes. Causes and Cures. Dayton, United Brethren Publishing House, 1903. 8vo, ix + 227 pp., portraits. $1.50 — MORELEY, MARGARET W. The Insect Folk. Boston, Ginn & Co., 1903. 8vo, vi–204 pp., many figs. NOÉ, J. Recherches sur la vie osscillante. Essai de biodynamique. Paris, Alcan, 1903. 8vo, 372 pp., 40 figs. 7 francs.— WATERS, C. E. Ferns. A manual for the Northeastern States with analytical keys based on the Stalks and on the Fructification. New York, Henry Holt & Co., 1903. 8vo, xi + 362 pp., over 200 figs. $3.00.— WELCKER, A. A Dream of Realms Beyond Us. San Francisco, Cubery & Co., 1903. 8vo, 38 pp.— WUNDT, W. Naturwissenschaft und Psychologie. Leipzig, Engelmann, 1903. 8vo, 126 pp., 3 marks.

ALVARD, H. E. and PEARSON, R. A. The Milk Supply of Two Hundred Cities and Towns. *U. S. Dept. Agr., Bureau Animal Industry Bull.* No. 46. 210 pp. — AMES, O. A New Species of Habenaria from Cuba. *Proc. Biol. Soc. Wash.* Vol. xvi, pp. 117–118. — ARNOLD, R. The Paleontology and Stratigraphy of the Marine Pliocene and Pleistocene of San Pedro, California. *Mem. Cal. Acad. Sci.* Vol. iii, 420 pp., 37 pls.— BEAN, B. A. Notice of a Small Collection of Fishes, including a Rare Eel, recently received from H. Maxwell Lefuoy, Bridgetown, Barbados, West Indies. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 903–964, 1 fig. — BAKER, C. F. On the Gnathodus Species of the

Abdominalis Group. *Invertebrata Pacifica.* Vol. i, pp. 1–12. — BARROWS, F. W. Economic Zoölogy. *Bull. Buffalo Soc. Nat. Sci.* Vol. viii. pp. 16. — BOHR, C. and HASSELBALCH, K. A. Om Fosterets Varmeproduktionog Stofskifte. *Oversigt. Kgl. Danske Videnks. Forhandl.*, 1903, No. 3, pp. 314–348, 3 figs.— CLARKE, S. F. An Alaskan Corymorpha-Like Hydroid. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 953–958, 5 figs.— COBB, J. N. The Sponge Fishery of Florida in 1900. *Rept. U. S. Fish Com.* for 1902, pp. 161–175, pls. 6–9. — COMSTOCK, F. M. A small Esker in Western New York. *Amer. Geol.* Vol. xxxii, pp. 12–14, pls. 2–3. — DALL, W. H. Synopsis of the Family of Astartidae with a Review of the American Species. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 933–951, pls. 62–63. — DAVENPORT, C. B. Cold Spring Harbor Monographs. II. The Collembola of Cold Spring Beach, with Special Reference to the Movements of the Poduridæ. *Bull. Brooklyn Inst. Arts & Sci.* 1903. 32 pp., 1 pl. — EIGENMANN, C. H. The Fresh-Water Fishes of Western Cuba. *Bull. U. S. Fish Com.* for 1902, pp. 211–236, pls. 19–21 and 15 text figs.— ELLIS, MARY. Index to Publications of the New York State Natural History Survey and New York State Museum 1837–1902. *Bull. N. Y. State Mus.* Miscellaneous No. 2. pp. 239–653. — EVERMANN, B. W. Statistics of the Fisheries of the Middle Atlantic States. *Rept. U. S. Fish Com.* for 1902. pp. 433–540.— FISHER, W. K. Birds of the Laysan and the Leeward Islands, Hawaian Group. *Bull. U. S. Fish Com.* for 1902, pp. 1–39, pls. 1–10. — GARCIA F. — Shade Trees and other Ornamentals. *Bull. New Mex. Agr. Exp. Sta.* No. 47, 55 pp., 29 figs. — GILL, T On some neglected Genera of Fishes. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 959, 962.— GILL, T. On some Fish Genera of the First Edition of Cuvier's Règne Animal and Oken's Names. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 965–967. — GOSS, A. Ash Analyses of some New Mexico Plants. *Bull. N. Mex. Agr. Exp. Sta.*, No. 44, 14 pp.— GRANT, M. Moose. *Seventh Ann. Rept. Forest Fish & Game Comm. State N. Y.*, pp. 225–238, 6 figs. — GUTHRIE, J. E. The Collembola of Minnesota. *Geol. & Nat. Hist. Surv. Minn.*, Zool. Ser. iv, 110 pp., 16 pls. — HELLER, E. and SNODGRASS, R. E. Papers from the Hopkins Stanford Galapagos Expedition, 1898–1899. XV. New Fishes. *Proc. Wash. Acad. Sci.* Vol. v, pp. 189–229, pls. 2–20. — HERRICK, C. J. The Degree and Sense of Taste in Fishes. *Bull. U. S. Fish. Com.*, for 1902, pp. 237–272, 3 figs.— SCHIMURA, T. On the Formation of Anthocyan in the Petaloid Calyx of the Red Japanese Hortense. *Journ. Coll. Sci. Imp. Univ. Tokyo.* Vol. xviii, 18 pp., 1 pl. — JENNINGS, H. S. Rotatoria of the United States. II. A Monograph of the Rattulidae. *Bull. U. S. Fish Com.* for 1902. pp. 273–352, pls. 1–15. — JOHANNSEN, O. A. Aquatic Nematocerous Diptera. *N. Y. State Mus. Bull.* No. 68. pp. 327–448, pls. 32, 50. — JONES, J. W. L. Sociality and Sympathy. Princeton Contributions to Psychology. Vol. iii, Nos. 3–4. — JORDAN, D. S. A Review of the Fishes of Japan belonging to the Family of Hexagrammidæ. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 1003–1013, 3 figs. — JORDAN, D. S. and EVERMANN, B. W. Descriptions of a New Genus and two New Species of Fishes from the Hawaian Islands. *Bull. U. S. Fish Com.* for 1902. pp. 209–210.— KELLOGG, J. L. Feeding Habits and Growth of Venus Mercernaria. *Bull. N. Y. State Mus.*, Zool. No. 10, 28 pp., 8 figs. — KENDALL, W. C. Notes on Some Fresh-Water Fishes from Maine. *Bull. U. S. Fish Com.* for 1902, pp. 353–368, 5 figs.— KENDALL, W. C. Habits of some of the Commercial Catfishes. *Bull. U. S. Fish Com.* for 1902. pp. 399–400. — LAMBERT, J. Description de Échinides

Crétacés de la Belgique principalement de ceux conservés au Musée royale de Bruxelles. *Mem. Mus. Roy. Hist. Nat. Belg.*, Tom. II, 150 pp., 6 pls. — MACOUN, J. Catalogue of Canadian Birds. Part. II. Birds of Prey, Woodpeckers, Flycatchers, Crows, Jays and Blackbirds including the following Orders: Raptores, Coccyges, Pici, Macrochires, and part of the Passeres. *Geol. Surv.*, pp. 230–415.— MARSH, M. C. A More Complete Description of Bacterium truttæ. *Bull. U. S. Fish Com.* for 1902, pp. 411–415, pls. 1–2. — MILLER, G. S., Jr. A Nataline Bat from the Bahamas. *Proc. Biol. Soc. Wash.* Vol. xvi, pp. 119–120. — MOENKHAUS, W. J. Description of a New Species of Darter from Tippecanoe Lake. *Bull. U. S. Fish Com.* for 1902. pp. 397–398, 1 fig. — MORSE, C. M. South Buffalo Floods and Proposed Remedy. *Bull. Buffalo Soc. Nat. Sci.* Vol. viii, pp. 16, maps. — NEEDHAM, J. G., MACGILLIVRAY, A. D., JOHANNSEN, O. A. and DAVIS, K. C. Aquatic Insects in New York State. *Bull. N. Y. State Mus.*, Entomology, No. 18. pp. 200–517, pls. 1–52.— NELSON, E. W. A New Squirrel from Central America. *Proc. Biol. Soc. Wash.* Vol. xvi, pp. 121–122. — NORDQUIST, O. Some Biological Reasons for the Present Distribution of Freshwater-Fish in Finland. *Fennia*, Vol. xx, pp. 29, map. — OBERHOLSER, H. C. The North American Forms of Astragalinus Psaltaria (Say). *Proc. Biol. Soc. Wash.* Vol. xvi, pp. 113–116. — PERKINS, O. P. Report on the Collections of Fishes made in the Hawaian Islands with Descriptions of New Species. *Bull. U. S. Fish Com.* for 1902. pp. 417–511, pls. 1–4.— PERKINS, R. C. L. The Leaf-Hopper of the Sugar Cane. *Board of Commissioners Agr. & Forestry Terr. Hawaii, Div. Ent. Bull.*, No. 1. 33 pp. — RICHARDSON, HARRIET. Isopods collected at the Hawaian Islands of the United States Fish Commission Steamer Albatross. *Bull. U. S. Fish Com.* for 1902. pp 47–54, 8 figs. — SCHALLER, W. T. Spodumene from San Diego Co., California. Univ. Cal. Publ., *Bull. Dept. Geol.* Vol. iii, pp. 265–275, pls. 25–27. — SCHWARZ, G. E.— The Diminished Flow of the Rock River in Wisconsin and Illinois and its Relation to the Surrounding Forests. *U. S. Dept. Agr. Bureau of Forestry Bull.* No. 44, 27 pp., 6 pls. — SHARPE, R. W. Report on the Fresh-Water Ostracoda of the United States National Museum, including a Revision of the Subfamilies and Genera of the Family Cyprididæ. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 969–1000, pls. 64–69. — SHERRARD, T. H. A Working Plan for Forest Lands in Hampton and Beaufort Counties; South Carolina. *U. S. Dept. Agr., Bureau of Forestry Bull.* No. 43. 54 pp., 13 pls. — SMALLWOOD, M. E. Cold Spring Harbor Monographs. I. The Beach Flea; Talorchestia longicornis. Brooklyn. *Bull. Brookl. Inst. Arts & Sci.*, 1903. 27 pp., 3 pls. — SMITH, H. M. The Common Names of the Basses and Sun-Fishes. *Rept. U. S. Fish Com.* for 1902, pp. 353–366. — SNOW, JULIA. The Plankton Algæ of Lake Erie, with Special Reference to the Chlorophyceæ. *Bull. U. S. Fish Com.* for 1902, pp. 369–394, pls. 1–4.— STEJNEGER, L. A New Hognose Snake from Florida. *Proc. Biol. Soc. Wash.* Vol. xvi, pp. 123–124. — STEVENSON, C. H. Aquatic Products in Arts and Industries. Fish Oils, Fats, and Waxes. Fertilizers from Aquatic Products. *Rept. U. S. Fish Com.* for 1902, pp. 177–279, pls. 10–25. — STEVENSON, C. H. Utilization of the Skins of Aquatic Animals. *Rept. U. S. Fish Com.* for 1902, pp. 281–352, pls. 26–38. — STEWART, J. H. and ATWOOD, H. Experiments with Buckwheat and Oats. *Bull. W. Va. Agr. Exp. Sta.* No. 84. pp. 467–480, 5 pls. — STEWART, J. H. and HITE, B. H. Commercial Fertilizers. *Bull. W. Va. Agr. Exp. Sta.* No. 85, pp. 110.— STONE, J. E. Injuries to Shade Trees from Electricity. *Bull. Mass. Agr. Exp. Sta.* No.

91. 21 pp., 12 figs.— TRUE, F. W. Notes on a Porpoise of the Genus Prodelphinus from the Hawaian Islands. *Bull. U. S. Fish Com.* for 1902, pp. 41–45, pls. 1–2.— VERNON, J. J. and LESTER, F. E. Pumping for Irrigation from Wells. *Bull. New Mex. Agr. Exp. Sta.*, No. 45. 67 pp., 35 figs. — VERNON, J. J. and TINSLEY, J. D. Soil Moisture Investigations for the Seasons of 1901 and 1902. *Bull. New. Mex. Agr. Exp. Sta.*, No 46. 46 pp.— WHITEEAVES, J. F. Notes on Some Canadian Specimens of "Lituites Undatus." *Ottawa Nat.* Vol. xvii, pp. 117–122.— WILCOX, W. A. The Fisheries and Fish Trade of Porto Rico in 1902. *Rept. U. S. Fish Com.* for 1902. pp. 367–395.— YASUDA, A. On the Comparative Anatomy of the Cucurbitaceæ, Wild and Cultivated in Japan. *Journ. Coll. Sci. Imp. Univ. Tokyo.* Vol. xviii, No. 4, pp. 56, 5 pls.

Aëronautical World, The. Vol. I, No. 11.— *American Inventor, The.* Vol. xi, No. 2.— *Annales de la Société Royale Malacologique de Belge.* Tom. xxxvi.— *Boletin de la Academia Nacional de Ciencias en Cordoba.* Tom. xvii, No. 3.— *Boletin de la Comision de Parasitologia Agricola.* Tom. ii, No. 2.— *Bulletin of the Children's Museum.* Brooklyn Institute of Arts and Sciences, No. 12, Sept.— *Bulletin Johns Hopkins Hospital.* Vol. xiv, Nos. 149–151.— *Deutche Arbeit.* Jahrg. i, Heft 12, Jahrg. ii, Heft 10.— *Journal of Applied Microscopy and Laboratory Methods.* Vol. vi, No. 7, July.— *Journal of Geography, The.* Vol. ii, No. 6, June.— *Missouri Botanical Garden.* Fourteenth Annual Report.— *Naturaleza, La.* Tom. iii, Nos. 5–10.— *Nuova Notarisia, La.* Ser. xiv, July.— *Papoose, The*, Aug.— *Plagas de la Agricultura Las.* Nos. 9–10, 2 pls., 3 text figs.— *Proceedings of the Rhodesia Scientific Association.* Vol. iv, Pt. 1, July.— *Revista Chilena de Historia Natural.* Am. vii, No. 2.— *School Science.* Vol. iii. No. 4, Oct.

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